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Rev. 1, Vol. II

ORBIT ANALYSIS SOFTWARE INDEX

Carole A. Boelitz
Eric V. Beck

July 1997

Final Report

PHILLIPS LABORATORY
Space Technology Directorate
AIR FORCE MATERIEL COMMAND
KIRTLAND AIR FORCE BASE, NM 87117-5776

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This report has been approved for publication.

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1996 Revision to replace/update PL-TR-95-1139. PL-TR-95-1139 will be separated into two parts from now on. Vol. I, the Orbit Analysis Software Survey is for U.S. Government Agency use only. Vol. II, the Orbit Analysis Software Index, is approved for public release, distribution unlimited.

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Approved for Public Release; Distribution is Unlimited

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13. ABSTRACT *(Maximum 200 Words)*

One goal of the Astrodynamics Division is to provide information on basic, standardized orbit analysis tools for Phillips Laboratory and AF space systems. The purpose of this orbit analysis survey is to list and measure the capabilities of existing commercial-off-the-shelf (COTS) and government furnished orbit analysis software packages. Consequently, military and civilian personnel can determine the best software package or complementary set of software packages to fulfill their needs while reducing acquisition costs and the need for in-house software support.

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Table of Contents

Acknowledgments

The authors would like to thank the software vendors listed in the software index for their purely voluntary participation in this report. In addition, the suggestions made by the software vendors who participated in the previous version of this report were taken into account in the preparation of this update. As the size of this report grows, so does it's usefulness to the Astrodynamics community as a central location of commercial-off-the-shelf (COTS), government-off-the-shelf (GOTS), shareware, and freeware orbit analysis and space mission software.

Introduction

One goal of the Astrodynamics team is to provide information on basic, standardized orbit analysis tools for Phillips Laboratory and AF space systems. The purpose of this orbit analysis survey is to list and measure the capabilities of existing commercial-off-the-shelf (COTS) and government furnished orbit analysis software packages. Therefore, AF personnel can determine the best software package or complementary set of software packages to fulfill their needs while reducing acquisition costs and the need for in-house software support.

Results and Discussion

During the course of this update, every effort was made by the authors to ensure that all the information contained in this report was current and accurate. However, due to the fluid nature orbit analysis software, many software packages are in a state of constant update. The information contained in this report was current at the time of the update. For the most recent version and capabilities of the software listed in this report, it is recommended that prospective buyers contact the software developers directly.

In addition, due to the large volume of orbit analysis software on the market commercially, it is a near impossible task to include every available software package which performs some aspect of orbit analysis. Any omission of any software package from this report was inadvertent, and the authors will be happy to include any software package not currently listed in this report in the next update.

Several government software 'clearinghouses' exist for orbit analysis and other scientific software on the Internet. Among them are:

- NASA's Software Technology Transfer Center (COSMIC) at http://www.cosmic.uga.edu. Software written by NASA, JPL, and other government agencies is distributed to the public through this center.
- United States Air Force Academy Department of Astronautics at http://www.usafa.af.mil/dfas. This site has various astrodynamics, systems and controls software, subroutines, and publications.

These sites also contain links to other astrodynamics related pages on the Internet. With very little effort, a great wealth of information about orbit analysis software can be found on the Internet, as well as many interesting astronautics and aerospace related links. Work is currently underway to produce an online version of this survey, in an effort to streamline distribution and dissemination of this information.

If there are any questions about any piece of software or the ratings that were executed, please feel free to contact the author at (505) 846-5963 (DSN 246-5963) or write to:

2Lt Eric V. Beck
PL/VTSA
3550 Aberdeen SE
Kirtland AFB, NM 87117-5776
becke@plk.af.mil

Orbit Analysis Software Index[i]

(8 July 1997)

If there are any additions or changes to this document or you would like to request an updated copy of this document (updates are available approximately every other year), please contact:

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3550 Aberdeen SE
Albuquerque, NM 87117-5776
becke@plk.af.mil
USA
Voice: (505) 846-5963
FAX: (505) 846-6053

NOTE: The author constantly tries to keep the index complete and accurate, but any omissions of packages or mistakes in capabilities or contacts are unintentional oversights of the author. Since this type of software is in such a dynamic environment, with existing packages in continuous upgrade and new packages always appearing on the market, the software package capabilities will change in time.

Advanced Simulation Development System (ASDS)

CONTACT:
McDonnell Douglas Aerospace - Houston Division
Dr. Robert Gottlieb (Technical)
(713) 283-1969
FAX: (713) 280-1631
13100 Space Center Blvd.
Houston, TX 77059-3556

- Library of reusable software components and developed applications

PURCHASE INFORMATION

- Cost: free
- Future developments: real-time capability, hardware in the loop, migration of parts to advanced object oriented languages (C++, Ada 9X), enhance modularity: increased interchangeable parts between languages, encapsulation of CASE tool autogenerated code, hierarchical simulation development (fidelity zooming)

SYSTEM REQUIREMENTS:

- Any system with compiler - software size varies with user needs

SOFTWARE STRUCTURE/SUPPORT:

- Library of reusable software components and developed applications with generic simulation framework (executive/input/initialization/discrete events/propagation)
- Written in FORTRAN/C/C++/Ada
- Open structure - modifications easy/designed to be portable
- Object oriented design
- Source code available
- Database of sites/vehicles/targets available with software

INPUT:

- GUI like input - smart editor with displayed options
- Database of vehicles available with software
- Complete Global Positioning System (GPS), IMU, star tracker, laser range, radar altimeter, doppler radar, propulsion, CMG, magnetic damper, & complete shuttle models

RUN-TIME OPTIONS:

- Restart capability

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PROPAGATOR:

- Numerical Cowell/BG-14 propagator with Runge-Kutta (1-4 order)/Runge-Kutta-Fehlberg (4-5th/7-8th order)/Runge-Kutta-Gill/Runge-Kutta-Shanks(8-10th order)/Runge-Kutta-Merson/Adams (4-6-8 order)/Nystrom-Lear (2-4-6 order)
- Can propagate forward/backward in time through integration/interpolation

PERTURBATIONS:

- Geopotential: GEM-6/GEM-9/GEM-10/GEM-L2/GEM-T1/GEM-T2/GEM-T3/WGS-84
- Selenopotential (moon) models: Konopliv 75x75/Sagitov 16x16/Liu-Laing 15x8/Bills-Ferrari 16x16/Ferrari 16x16
- Atmospheric drag: Jacchia 1970)/US Standard 1976/Babb-Mueller/SpaceCom Jacchia
- Aeropotential models: MGM-574 50x50/GMM-1 50x50
- Mars Atmospheric models: Stewart time dependent
- Solar radiation pressure
- Earth/ocean tides/side-force wind effects

PLANETARY:

- Sun/Moon/planetary positions
- Star catalogue
- Planetary ephemeris origin (JPL tape numerically integrated, Van Flandern analytical)
- Interplanetary targeting (matched conic, over-lapped conic, multi-conic, precise integration)

ANALYSES:

- Multi-site/vehicle simulation
- Monte Carlo dispersion analysis
- 3 DOF/6DOF/nDOF (multi rigid body) vehicle dynamics simulation
- Optimization through iteration
- Contacts with Space Station/near asteroid passes
- Ground coverage analysis

GRAPHICS:

- Maps: zoomable/Mercator

FEATURES:

- Dependent variable control through Regula-Falsi
- Vehicle specific hardware & flight software models
- ASDS based applications: 14 element VOP, GNC Integrated Simulation, Station Trajectory Analysis & Reboost Simulation, Automated Rendezvous & Capture Simulation, Threat Missile Simulation, Simulation for Monte Carlo Analysis of Aeroassist and Reentry Trajectory Spacecraft, Lunar Exploration Simulation, Restricted 3 body Targeting & Restricted 3 Body HALO Orbit Simulations, Near Earth Asteroid Rendezvous Tool, Unrestricted 4 body optimization tool, Space Shuttle 6DOF Ascent Simulation, Space Shuttle 6DOF on-orbit Simulation, Space Shuttle 6DOF Descent Simulation, Generic 3DOF Simulation

USERS:

- Johnson Space Center, Marshall Space Flight Center, Goddard Space Flight Center, Space Station Flight Planning, USASSDC, McDonnell Douglas, IBM, Loral, Booz-Allen

CONCERNS:

- Requires external program for plot package

AMOEBA

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Tom Gurlitz
(703) 808-2454

- Satellite ground station contacts and station visibility analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC

OUTPUT FORMAT:

- Screen plot (2D line)

OUTPUT CONTENT:

- Time history of longitude of ascending node
- Visibility between site and satellite

ANALYSES:

- Ground coverage analysis

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

Analytical Orbit Determination (ANODE) Program

CONTACT:

MIT Lincoln Laboratory
244 Wood St.
Lexington, MA 02173
Jayant Sharma
(617) 981-4774
FAX: (617) 981-0991
e-mail: sharma@ll.mit.edu

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: upon request

SYSTEM REQUIREMENTS:

- Workstation
- Hard Drive Space: Source Code - 3 MB; Executable - 1 MB; Data files - 1 MB
- Media Format: Data tape/disks

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Source code available
- Documentation available with user information
- Software verified with Lincoln Laboratory software and operational orbit data by Lincoln Laboratory

INPUT:

- GUI interactive menu

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: AU (astronomical unit-Earth-Sun mean distance)/DU (distance unit - Earth Radii)/kilometers (input/output)
- Angle: degree
- Time: days (input) - days/Hours (for any time zone)/Minutes/Seconds (output)
- Internal Units: days/DU, AU/radian

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (output)
- Mean NORAD 2-line element set

PROPAGATOR:

- Numerical propagator
- Analytical propagator: SGP4/SDP4
- Can limit to two body
- Coordinate system: Earth true equator mean equinox of epoch/true equator true equinox of 1JAN2000.00:00:00 (input/output/internal)
- Maximum altitude = > 36,000 km
- Minimum altitude = , 500 km (72,000 km for deep space)

PERTURBATIONS:

- Geopotential: none/J2/J3/J4/GEM-T1 (36x36)
- Analytically propagated lunar/solar/n body effects
- Relativistic effects
- Central body replacement for extra-terrestrial orbits

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Planetary ephemeris origin: JPL DE-200
- Allows interplanetary trajectory (heliocentric)
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Element set from propagator

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package

Artificial Satellite Analysis Program (ASAP)

CONTACT:

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
Johnny H. Kwok
Mail Station 301-170S
(818) 354-6776
FAX: (818) 393-9815
e-mail: johnny.h.kwok@jpl.nasa.gov
NASA Cosmic Order #NPO-17522
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Propagator for analyzing satellite behavior over several months

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $300 + $19 documentation

SYSTEM REQUIREMENTS:

- PC - 80x86 with math co-processor
- Operating system: MS-DOS®
- RAM: 64 MB
- Hard Drive Space: Source Code - 400 KB; Executable - 125 KB MB
- Media Format: Disk

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Source code available
- Documentation available with technical/user information
- Software verified against JPL DPTRAJ by author

INPUT:

- Column formatted file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (LOTUS 1-2-3)

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating)

UNITS:

- Distance: kilometers (input/output)
- Angle: degree (input/output)
- Time: Calendar date/Hours/Minutes/Seconds (input/output)
- Internal Units: seconds/kilometers/radians
- Input and output units must be the same

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating Modified Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (output)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 7-8th order with variable step size
- Coordinate system: Earth mean equator of epoch (input/output/internal)

- Maximum altitude = >36,000 km
- Minimum altitude = < 500 km

PERTURBATIONS:

- Geopotential: GEM 10B (40x40)/user supplied
- Atmospheric drag: static exponential/US Standard 1976
- Solar radiation pressure with cylindrical shadow modeling
- Analytically propagated lunar/solar body effects
- Central body replacement for extra-terrestrial orbits
- Spacecraft modeling: mass/drag coefficient/cross-sectional area

PLANETARY:

- Sun/planetary positions
- Planetary ephemeris origin through user input (Almanac)
- Allows interplanetary trajectory (heliocentric)
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Element set from propagator (position-velocity/equinoctial/classical Keplerian)

ANALYSES:

- GEO drift cycle
- Venus mapping
- Mars frozen orbit/repeat ground track

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package

ASTROALL

CONTACT:

United States Air Force
PL/VTS
Maj. David Vallado
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-4056

- General purpose mission analysis

PURCHASE INFORMATION:
- Cost: free
- New release in Summer 1996

SYSTEM REQUIREMENTS:
- PC

SOFTWARE STRUCTURE/SUPPORT:
- Written in PASCAL with double precision
- Open structure - modifications easy/designed to be portable
- Source code available (Methods of Astrodynamics)

INPUT:
- Keyboard prompted
- Can load sites/vehicles/targets from database

RUN-TIME OPTIONS:
- Quit/pause
- Increase/decrease/return to original simulation step size

OUTPUT FORMAT:
- ASCII/text data

CONVERSION/TRANSFER:
- Between element sets: Cartesian position and velocity/Classical and vice versa
- Between hour-min-sec/degree-min-second to radians and vice versa
- Converts between Calendar date with time/GMT/LST/GST/Julian Date/Day of Year

UNITS:
- Distance: AU (astronomical unit-Earth-Sun mean distance)/DU (distance unit - Earth Radii)
- Time: TU (time unit)

PROPAGATOR:
- Numerical Cowell with Runge-Kutta (4th order)
- Can limit to two body

PERTURBATIONS:
- Geopotential: none/J2/J3/J4
- Atmospheric drag: Static exponential
- Solar radiation pressure
- Lunar/solar body effects

ORBIT DETERMINATION:
- Gibbs: determines middle velocity vector from 3 position vectors
- Herrick-Gibbs: determines middle velocity from 3 position vectors and times
- Simple orbit determination (coordinate transfer) from complete radar data: azimuth/azimuth-rate/elevation/elevation-rate/range/range-rate

BALLISTIC/LAUNCH TRAJECTORY:
- Calculates trajectory given latitude/longitude of launch and target

ORBIT MANEUVERS:

- Calculates time of flight and velocity needed for Hohmann/one tangent burn transfer between two orbits
- Determines velocity needed to intercept target (Gauss Method - given R1, R2, Direction, Time of Flight)
- Determines velocity needed to rendezvous target (Hill Method)

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Planetary ephemerides in position and velocity/Classical Keplerian
- Allows interplanetary trajectory (heliocentric)

OUTPUT CONTENT:

- Interim calculations
- Save to file/Print to laser/dot matrix printer
- Element set by orbit determination from input/simulated observations (azimuth/azimuth-rate/elevation/elevation-rate/range/range-rate)
- Visibility azimuth/azimuth-rate/elevation/elevation-rate/range/range-rate/topocentric right ascension and declination between site/satellite
- Re-entry predict (Allen-Eggars approximation)

ANALYSES:

- Comparison between orbit propagators (2 body/2 body + J2) in ECI position and Velocity/Classical Keplerian
- Ground coverage analysis

GROUND SITES:

- Defined by geodetic latitude/longitude/altitude

GRAPHICS:

- Maps: Mercator
- Save to file/Print to laser/dot matrix printer
- Ground track for one satellite

FEATURES:

- On-line astrodynamic calculator
- Find C&S coefficients

CONCERNS:

- Some features not fully tested
- No user documentation (through Vallado book release in Summer, 1996)
- No/Limited support group available

ASTROVIS v4.5

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Richard Casten
(310) 336-8622
James A Paget
(310) 336-0301
FAX: (310) 336-7612

- Comprehensive orbit mission analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC/NEXT/UNIX Workstation

SOFTWARE STRUCTURE/SUPPORT:

- Written in C
- Open structure - modifications easy/designed to be portable
- Support group available (Richard Casten and Jim Paget)
- Number of sites/satellites limited only by memory
- Interfaces with external programs: POWER

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database
- Can accept propagator input from external program
- Database of sites/vehicles/targets available with software
- Can save/load whole scenario/configuration
- External program written to accept NORAD catalog though disk/file
- Constellation input (Walker system - set initial sat and # planes and # sats)

OUTPUT FORMAT:

- ASCII/text data

CONVERSION/TRANSFER:

- Between element sets: Cartesian position and velocity/Classical/NORAD 2-line (one way - NORAD to osculating)

UNITS:

- Distance: feet/nautical miles/statute miles/kilometers
- Angle: radian/degree
- Time: Calendar date/Hours/Minutes/Seconds/Julian Date
- Can convert values
- Can change unit type and keep value static

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating equinoctial (input/output) (F&G)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating geoclassical (input/output) (latitude/longitude/inclination/argument of perigee/perigee altitude/apogee altitude)
- Osculating neoclassical (input/output) (latitude/longitude/inclination/argument of perigee/semi-major axis/eccentricity)

- Osculating spherical (input/output) (right ascension/declination/flight path angle/azimuth/range from geocenter/inertial speed)
- Osculating geographic (input/output) (latitude/longitude/flight path angle/azimuth/range from geocenter/inertial speed)
- Mean NORAD 2-line element set

PROPAGATOR:

- Analytical propagator: two body/two body + J2/SGP4
- Can limit to two body

PERTURBATIONS:

- Geopotential: none/J2

BALLISTIC/LAUNCH TRAJECTORY:

- Output from POWER is compatible

PLANETARY:

- Sun/Moon positions and velocities

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history options: time from epoch/date and time/Julian Date
- Time history of latitude/longitude/equator crossing times/longitude of ascending node
- Element set from propagator
- Visibility azimuth/azimuth-rate/elevation/elevation-rate/range/range-rate between site/satellite and satellite/satellite
- Output can be limited to time of constraint satisfaction
- Constraint satisfaction summary profile (average length/average gap/minimum length/maximum gap)
- Sun rise/set times
- Object in sunlight
- Satellite heading N/S

ANALYSES:

- Multi-site/vehicle simulation
- Ground coverage analysis

GROUND SITES:

- Defined by geodetic latitude/longitude/altitude/ID (text/symbol)
- Ground sensor defined by elevation (min/max)/azimuth (min/max)/range (min/max)

SENSOR OPTIONS:

- Define sensor cone with elevation (min/max)/azimuth (min/max)/range (min/max)/antenna parameters
- Set pointing constraints: nadir pointing/fixed with respect to vehicle/fixed with respect to inertial frame/aimed at point on Earth (for instantaneous footprint graphics only)/aimed at horizon at specified latitude (for instantaneous footprint graphics only)
- Can define multiple sensors per satellite (up to two)
- Can define complex systems of sensors/constraints with and/or/not/at least between sites/vehicles/targets

TARGETS/VEHICLES:

- Can create areas of interest for plotting only

GRAPHICS:

- Maps: zoomable/Mercator/ 3D perspective (spherical Earth)
- Maps show coastlines/islands/countries/states/lakes/rivers
- Ground tracks for all satellites
- Sensor ground swaths/instantaneous sensor coverage/Earth coverage contours
- Ground station coverage contours with unique text/general symbol ID
- Any text can be added to graphics within program

CONCERNS:

- Limited support group available (Richard Casten and Jim Paget)

- Static program - no plans to update/being absorbed in to another program
- Requires external program for ballistic trajectory analysis
- In determining if satellite lit by sun, uses satellite sub-point rather than satellite position (i.e. altitude = 0)
- Being absorbed into PC SOAP
- Station contours are for a specified altitude (not satellite point of view)
- In determining satellite eclipsing, the satellite Earth sub-point is considered, not the satellite at its altitude

ATLAS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Jim Gidney
(310) 336-8578

- Timeliner and scheduling program

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC
- Coded in APL

FEATURES:

- Graphic timeline/schedule of activities/events (ground site contacts during ascent phase of mission)

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

AXIS

CONTACT:

Science Applications International Corporation (SAIC)
Jeff Knox
(619) 546-6105

- Display tool to add on to existing code to analyze ballistic missile defense concepts

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- UNIX

SOFTWARE STRUCTURE/SUPPORT:

- X-Windows/MOTIF used for GUI
- Open structure - modifications easy/designed to be portable
- Source code available
- Documentation available with technical/user information
- Support group available
- Interfaces with external programs: MAM/STAMP/STAMP DB/STRATC2AM/NATEIFEC to enhance missile displays
- Software origin from: GATE with added communications/SDI sensor alignment/ reconnaissance analysis displays

INPUT:

- GUI interactive menu
- Database of sites/vehicles/targets available with software

RUN-TIME OPTIONS:

- Simulation playback

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D line/3D contour)

OUTPUT CONTENT:

- Time history
- Visibility between any site/vehicle/target

ANALYSES:

- Multi-site/vehicle/target simulation

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation/azimuth

GRAPHICS:

- Maps: zoomable/Mercator/ 3D perspective (spherical Earth)
- Map shows Earth altitude through color (relief)
- Orbit tracks for all satellites/missiles
- Sensor view window

FEATURES:

- Communication link filters/metric display
- Includes radar fans
- Threat/trajectory color changes when detected
- Launch sites/impact points
- To analyze/filter communications: can enter probability of receipt, signal to interference ratio, types, frequency bands, transmitter classes, receiver classes, node classes, node names

CONCERNS:

- Not a complete orbit analysis package
- Not specifically developed for orbit analysis applications

COMET

CONTACT:

The RAND Corp.
1700 Main St.
PO BOX 2138
Santa Monica, CA 90407-2138
Dr. Michael D. Miller
(310) 393-0411

- 3 DOF missile launch through atmosphere and gravitational field simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN
- Source code available

INPUT:

- Column formatted file
- Ballistic input: initial element set with all information needed to calculate vehicle acceleration throughout trajectory

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Distance: feet/kilometers
- Mass: Lb./Kg
- Input and output units must be the same

ELEMENT TYPES:

- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)
- Osculating Inertial Polar position and velocity (input/output)
- Osculating Earth Fixed Polar position and velocity (input/output)

PROPAGATOR:

- Numerical Adams-Moulton (4th order) predictor-corrector integrator with variable step size

PERTURBATIONS:

- Atmospheric drag: Air Research and Development Command Model (1st order)
- Aeropotential models: pressure/speed of sound
- Spacecraft modeling: mass (computed for spherical Earth)/aerodynamic drag coefficient as function of Mach number (user/table input) (no side forces/moments/lift)
- Coriolis and centrifugal pseudoforces throughout trajectory (ballistic trajectory)

BALLISTIC/LAUNCH TRAJECTORY:

- Customize up to 6 stages
- 3D thrust control at each stage
- Assumes constant vacuum thrust and fuel flow rate (no throttle control)
- Avoids singularities of transpolar trajectories
- Launch from space/air-borne platforms (initial relative velocity with respect to Earth)
- Initial vertical ascent with turn towards specified azimuth
- Interstage coasting
- Instantaneous mass losses during burn/coast

OUTPUT CONTENT:

- Element set from propagator (position-velocity)

FEATURES:

- Database of drag coefficients for low drag/solid propellant rocket/big fueled space booster/high drag configurations
- User defines maximum allowed error to optimize time step in propagator
- User can set minimum step size and program will notify if convergence problems arise

CONCERNS:

- Not a complete orbit analysis package
- Limited external distribution (Protected by Arms Export Control Act)
- Not specifically developed for orbit analysis applications
- Spherically symmetric Earth
- Limited error checking on input
- Earth constants may need updating (ER = 6375.58 km)

Communications Link Analysis and Simulation Systems (CLASS)

CONTACT:

NASA - Goddard Space Flight Center
Greenbelt, MD 20771
The Networks Division
Telecommunications Branch
(301) 286-5089
World Wide Web (http://snas.gsfc.nasa.gov)

- Evaluates communication performance through NASA's Space Network, Ground Network, and Deep Space Network by modeling TDRSS constellation, user spacecraft, White Sands Complex, and Ground Network Terminals

PURCHASE INFORMATION:
- Cost: Unknown

SYSTEM REQUIREMENTS:
- Unknown

SOFTWARE STRUCTURE/SUPPORT:
- Open structure - modifications easy
- Training courses available

INPUT:
- Can load sites/vehicles/targets from modem/Internet

OUTPUT FORMAT:
- Screen plot (2D line)

PROPAGATOR:
- Can limit to two body

PERTURBATIONS:
- Geopotential: none/J2
- Atmospheric drag
- Solar radiation pressure
- Lunar/solar body effects

ORBIT MANEUVERS:
- Input thrust

OUTPUT CONTENT:
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate between site/satellite and satellite/satellite

ANALYSES:
- Multi-site/vehicle simulation
- Ground coverage analysis

GRAPHICS:
- Maps: Mercator
- Instantaneous sensor footprint

FEATURES:
- Can be used for spacecraft design, mission planning, and interference avoidance
- Evaluates: bit error rate, link margins, synchronization performance, geometric coverage, antenna design, autotrack performance, and acquisition times
- Models: transmitter/receiver hardware characteristics and dynamics, satellite/satellite and satellite-site channel characteristics, system self-interference, radio frequency interference (RFI), environmental effects and others
- Optimum TDRSS coverage with steering units
- RFI zone calculation/analysis/simulation

- Flux density analysis
- Minimum power received & minimum G/T analysis
- Attitude generation
- Hardware distortion/emulation
- Link margin/BER analyses
- Antenna placement analysis/antenna blockage and multipath analysis
- Rain/atmospheric attenuation analysis
- Mutual interference analysis
- Compatibility assessment
- Tracking performance
- On-line network advisory messages
- Custom telecommunications analyses of any type

CONCERNS:

- Not a complete orbit analysis package
- Not specifically developed for orbit analysis applications (optimized for communications analyses)

Cyberspace Data Monitoring System

CONTACT:

Jet Propulsion Laboratory
Information Systems Development and Operations Division
Robert Angelino

- NASA's new catalogue monitoring software for on-orbit operations system status

PURCHASE INFORMATION:

- Cost: in prototype

SYSTEM REQUIREMENTS:

- SGI

SOFTWARE STRUCTURE/SUPPORT:

- Written in C
- Open structure - designed to be portable to other UNIX platforms

FEATURES:

- Uses colored grids to display satellite data
- Uses colors and shapes rather than alpha-numeric data to denote different channels and values
- Can zoom in on subsystem information

CONCERNS:

- Not a complete orbit analysis package
- Not commercially available (still in prototype/beta test)

COVERIT

CONTACT:

The Aerospace Corporation
Chris Kobel
(310) 336-7861
PO Box 92957
Los Angeles CA 90245-2957

- Color contour display of coverage and revisit characteristics on a world map

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- PC

ANALYSES:

- Ground coverage analysis

CONCERNS:

- Not a complete orbit analysis package

DAB Ascent & Database

CONTACT:

DAB Engineering
2155 South Valley Highway Suite 201
Denver, CO 80222
(303) 757-6425
FAX: (303) 757-1215

- Advanced launch vehicle design, propulsion trade studies, payload/vehicle matching, and generating performance curves

PURCHASE INFORMATION:

- Cost: $7,495 for Microsoft® Windows™, Macintosh
- Cost: $9,995 for UNIX
- Future developments: Microsoft® Windows™ version in progress

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Interfaces with external programs: Satellite Tool Kit
- Accuracy of 99.4% in payload

INPUT:

- GUI interactive menu
- Complete international database of vehicles available with software

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (HPGL file for MS Word, PowerPoint, WordPerfect...)
- Screen plot (2D line) (over 40 parameters including gravity loss, Q-alpha, or Mach)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order with variable step size 3-5 sec recommended and adjusted by program so smaller during atmospheric phase of flight and so flight events are not stepped over - i.e. thrust table entry, control change, stage ignition time, and stage release time)

PERTURBATIONS:

- Geopotential: J2
- Atmospheric drag: US Standard 1976 with rotating planet/user defined atmospheric table (density pressure/speed of sound/temperature) (no limit to number of entries)
- Side-force wind effects/buoyancy/lift/user defined wind through table
- Central body replacement for extra-terrestrial orbits
- Vehicle attitude: 3DOF/no rotational dynamics/no moments of inertia/no torque
- Engine thrusters (includes pressure losses/propellant temperature effects)

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation and optimization
- Tracks vehicle orientation in 3D - no rotational dynamics/no moments of inertia/no torque
- Customize up to n stages
- 3D thrust control/flow rate/time of ignition & release/aerodynamic coefficients by Mach number/angle of attack/angle of yaw at each stage
- Launch from air-borne platforms (initial relative velocity with respect to Earth)
- Instantaneous mass losses during burn/coast
- Impact latitude/longitude calculated/marked in graphics ASCII output for each stage

OUTPUT CONTENT:

- Save to file/Print to HP laser printer
- Time history of acceleration/mass/burn-out conditions/program status

GROUND SITES:

- Defined by latitude/longitude/altitude

GRAPHICS:

- Maps: zoomable/Mercator
- Save to file/Print to HP laser printer
- Ground tracks for vehicle (can see impact point if engine fails)
- Animated graphics in simulation
- View vehicle attitude (in launch frame of reference)

FEATURES:

- Now available as STK module (integrated via STK/IPC)
- Launch model visualization through STK/VO
- Graphic timeline/schedule of activities/events
- Displays 3D vectors of inertial and relative velocity and aerodynamic forces
- Model any international launch vehicle including air-launch Pegasus
- Model any untargeted sounding rocket or solve for orbital injection parameters while maximizing either burnout velocity or payload mass
- Flight controls: hold to launch pad, fly relative to Vr, find optimal pitch and yaw rates, inertial rotation, fly relative to Vi
- Aerodynamics specified through Mach number, six coefficients for zero angle drag, lift, and side force as well as the rates of change of drag, lift, and side force with respect to total angle of attack, angle of attack, and angle of side slip respectively; in either body relative or Vinf relative coordinates
- Target options: radius, inertial flight path angle, inclination, right ascension of ascending node, and/or velocity - met through steering commands and/or adjusting ballast mass
- Optimization methods built in

CONCERNS:

- Not a complete orbit analysis package
- Not specifically developed for orbit analysis applications (launch)

DAB Orbit

CONTACT:

DAB Engineering
David A Baker
2155 South Valley Highway Suite 201
Denver, CO 80222
(303) 757-6425
FAX: (303) 757-1215
E-mail: dbaker@dab.com

- 3DOF satellite orbit maneuver simulation - models spacecraft position in 3 dimensions.

PURCHASE INFORMATION:

- Cost: $1,995
- Future developments: Microsoft® Windows™ version in progress

SYSTEM REQUIREMENTS:

- 386/486 PC
- Operating system: MS-DOS®
- RAM: 640 KB
- Hard Drive Space: Executable - 500 KB; Data files - 200 KB
- Media Format: Disk

SOFTWARE STRUCTURE/SUPPORT:

- Written in C/C++ with double precision
- Documentation available with user information
- Software verified against OMNI and QUICK
- Number of satellites limited to 1 per simulation
- Interfaces with external programs: Satellite Tool Kit

INPUT:

- Column formatted file
- GUI interactive menu
- Complete international database of vehicles available with software

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (HPGL file for MS Word, PowerPoint, WordPerfect...)
- Screen plot (2D line) (over 40 parameters)

UNITS:

- Distance: kilometers (input/output)
- Angle: degree
- Time: Calendar date/Seconds/Julian Date
- Internal Units: kilometers/Julian date/radian

ELEMENT TYPES:

- Mean Classical Keplerian (input/output)
- Mean Modified Keplerian (input/output)
- Mean Earth Centered Inertial position and velocity (input/output)
- Spherical (input/output) (right ascention/declination/C3/other angles for hyperbolic input)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order with variable step size (3-5 sec recommended and adjusted by program so flight events are not stepped over)
- Coordinate system: Earth mean equator mean equinox of 1JAN2000.00:00:00 (input/output/internal)
- Can limit to two body

- Minimum altitude = 0 km
- Can simulate rectilinear/parabolic/hyperbolic orbits

PERTURBATIONS:
- Geopotential: J2
- Atmospheric drag: US Standard 1976 with rotating planet/user defined atmospheric table (density pressure/speed of sound/temperature) (no limit to number of entries)
- Mars Atmospheric models
- Central body replacement for extra-terrestrial orbits
- Spacecraft modeling: mass/drag coefficient/cross-sectional area/thrust/flow rate
- Vehicle attitude: 3DOF/no rotational dynamics/no moments of inertia/no torque (set initial pitch and yaw and rates of each)
- Engine thrusters (includes pressure losses/propellant temperature effects)

ORBIT MANEUVERS:
- Coast/Impulse/Finite burns
- Input thrust vector in spacecraft/inertial coordinate frame
- Simulates stationkeeping maneuvers
- Determines velocity needed to intercept target (Gauss Method - given R1, R2, Direction, Time of Flight)
- Determines velocity needed to rendezvous target (many target conditions - optimization)
- Pre-set burn/coast times

PLANETARY:
- Predicts Earth/Lunar eclipses with cylindrical modeling
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:
- Time history of acceleration/mass
- Element set from propagator (Classical Keplerian)

ANALYSES:
- 3 DOF vehicle dynamics simulation
- Optimization through iteration

GRAPHICS:
- Maps: zoomable/Mercator
- Save to file/Print to HP laser printer
- Ground tracks for each satellite
- Displays thrust segments graphically

FEATURES:
- Participated in Orbit Propagator Software Survey
- Targets final conditions while maximizing payload mass
- Finite thrust to mass ratio simulated
- Many options for target selection (C3,Right Ascension of Asymptote, Declination of Asymptote, Radius, Velocity, Flight Path Angle, Inclination, Right Ascension of Ascension Node, Argument of Perigee, Declination of vehicle position, Periapsis radius, Apoapsis Radius
- Can define any number of coast/thrust events - coast time, Delta V, thrust, Engine mass flow rate, pitch, yaw, pitch rate, and yaw rate
- Includes low thrust electric propulsion, GEO delivery from LEO, planetary capture at Earth, planetary departure from Earth, Molniya mission delivery demos
- Can study aerobraking using periapsis altitude to control depth of atmospheric penetration

CONCERNS:
- Not a complete orbit analysis package

Debris

CONTACT:

The Aerospace Corp.
Deanna Maines
M4-947
(310) 336-8570
deanna.maines@aero.org
PO Box 92957
Los Angeles CA 90245-2957

- Debris analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Cray

ANALYSES:

- Probability of collision
- Debris analysis

CONCERNS:

- Not a complete orbit analysis package

Debris Cloud Simulation Tool (DCSIM)

CONTACT:

The Aerospace Corp.
Deanna Maines
M4-947
(310) 336-8570
deanna.maines@aero.org
PO Box 92957
Los Angeles CA 90245-2957

- Graphically simulates debris fragments and satellites for visualization and demonstration

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- Hosted on Silicon Graphics workstation

SOFTWARE STRUCTURE/SUPPORT:

- Written in C

ANALYSES:

- Debris analysis

CONCERNS:

- Not a complete orbit analysis package

Decay

CONTACT:

Orion International
(505) 881-2500

- Orbit decay simulation

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- Any platform with FORTRAN compiler

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

PROPAGATOR:

- Semi-analytic mean propagator (Orbit Type 3)
- Mean analytical propagator (Orbit Type 1 & 2)
- Maximum altitude = 2000 km (perigee), 40000 km (apogee)
- Minimum altitude = 90 km (perigee), 125 km (apogee)

PERTURBATIONS:

- Geopotential: none (Orbit Type 1)/J2 (Orbit Type 2 & 3)
- Atmospheric drag: King-Hele (Orbit Type 1)
- Analytically propagated lunar/solar body effects (Orbit Type 2 & 3)

OUTPUT CONTENT:

- Lifetime analysis/re-entry predict

FEATURES:

- Will not give correct answer if resonance present
- Orbit Type 1 - low apogee altitudes and sun/moon perturbations may be neglected as well as geopotential (does not effect overall picture) - King-Hele method
- Orbit Type 2 - lifetime strongly affected by sun/moon and lifetime greater than 4 years - calculates analytically effect on perigee density then substitutes into King-Hele
- Orbit Type 3 - lifetimes strongly affected by sun/moon and lifetime less than four years - semi-analytical time step - uses 60 day step sizes

CONCERNS:

- Not a complete orbit analysis package

Defense Support Program Medium Fidelity Model (DSP MFM)

CONTACT:

Space Warfare Center
SWC/AEW
720 Irwin Ave. Suite 2
Falcon AFB, CO 80912-7202

- Specialized satellite vehicle and ground site analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Unknown

FEATURES:

- Flight vehicle geometry and coordinate transformations (spin & optical)
- Sensor functions: cell by cell response, focal plane age and temperature, target signature, atmospheric attenuation
- Ground Station functions: data discard (cell unique thresholding, defective cells, solar blanking from secular reflections), Clustering and centroding (adjustments for optical blur and target extent), data association, track formation, Tactical parameter estimation, correlation, quick look and follow on event processing, message generation

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

Donuts

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Jim Paget
(310) 336-0301

- Launch window plots

CONCERNS:

- Not a complete orbit analysis package

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- IBM 3090

CONCERNS:

- Not a complete orbit analysis package
- Outdated software – may not be available

DPTRAJ/ODP

CONTACT:

NASA with Caltech & JPL
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #NPO-17201
email: service@cosmic.uga.edu

- High accuracy trajectory analysis and orbit determination program for deep space/interplanetary missions

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $7,000 + $144 documentation

SYSTEM REQUIREMENTS:

- Dec VAX with VMS

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN V(PL/I)/SFTRA/Assembler with double precision
- Documentation available

PROPAGATOR:

- Numerical propagator

PERTURBATIONS:

- Central body replacement for extra-terrestrial orbits

PLANETARY:

- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

FEATURES:

- DPTRAJ - high precision numerical integration
- ODP - precise orbit estimates of satellite, lander, or position coordinate histories

USERS:

- Voyager mission analysis

CONCERNS:

- Not a complete orbit analysis package

Draper Research and Development Goddard Trajectory and Determination System (GTDS)

CONTACT:

Draper Laboratory
Dr. Paul Cefola
555 Technology Sq.
Cambridge MA 02139
(617) 258-1787
FAX: (617) 258-1131

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: free
- Future developments: GUI

SYSTEM REQUIREMENTS:

- VAX/Sun/SGI/80486 PC/Mac
- Operating system: MS-DOS® 5.0 or higher (PC)
- RAM: 16 MB (PC)
- Hard Drive Space: Executable - 10 MB (PC); Data files - 40 MB + 50 MB for scratch/input (PC)
- Media Format: CD-ROM (PC)

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/FORTRAN 90/PASCAL with double precision
- MS-DOS® version 5 used for UI
- Documentation available with technical/user information
- Software origin from: Goddard Space Flight Center GTDS

INPUT:

- PC UI interactive menu with Phillips Laboratory User Interface (Astrodynamics Branch/3550 Aberdeen SE/Albuquerque/NM/87117-5776)
- Column formatted file
- Binary file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Binary file

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: kilometer/meter
- Angle: degree/minute/second
- Time: UTC (input) and TAI/Universal/UTC/Leap second adjustments (output)

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating equinoctial (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (FK4/FK5) (input/output)
- Mean/Osculating Earth Centered Earth Fixed position and velocity (input/output)
- Mean/Osculating spherical (input/output)
- Mean NORAD 2-line element set (input)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order predictor-corrector integrator with variable step size
- Semi-analytic mean propagator: Draper (mean + short periodics)/Semi Analytic Liu Theory (SALT)

- Analytical propagator: SGP/SGP4/DP4/Brouwer-Lyddane mean element/HANDE
- Can propagate forward/backward in time through integration/interpolation
- Coordinate system: Earth mean equator mean equinox of 1 Jan 1950.00:00:00 (input/output)/true equator true equinox of 1 Jan 1950.00:00:00 (input/output)/true equator true equinox of 1 Jan 2000.00:00:00 (output)/mean equator mean equinox of 1 Jan 2000.00:00:00 (output)

PERTURBATIONS:

- Geopotential: GEM-10B (36x36)/GEM-L2 (21x21)/GEM-T2/GEM-T3 (50x50)/GEM-T3S/WGS-72 (21x21)/WGS-84 (21x21) or (41x41)/JGM-2 (50x50)
- Atmospheric drag: exponential/MSIS 1983/Jacchia 1964/1971)/Harris-Priester/Jacchia-Roberts
- Solar radiation pressure with cylindrical/conical shadow modeling
- Lunar/solar/n body effects
- Relativistic effects/precession/nutation/delta UT1/pole wander
- Central body replacement for extra-terrestrial orbits
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Weighted Least Squares (batch and sequential)/Kalman filter/Extended Kalman filter with parameter constraints
- Manual/automatic smoothing/culling of incoming data
- Observation types: radar/laser ranging/telescope (angles only)/Global Positioning system (GPS)/Ephemeris/MANS dual cone scanner with sun fans as measurement type (PL TAOS satellite)
- Measurements: range/azimuth/elevation/azimuth rate/elevation rate
- Solve for parameters: geopotential/solar radiation pressure/atmospheric drag/station coordinates and velocities/pass dependent (range biases/refraction/clock errors)/data error correction /residuals/weighted RMS/percent data included
- Allows a priori data for all estimates and uncertainties of all parameters

ORBIT MANEUVERS:

- Impulse/Finite burns
- Input thrust vector in spacecraft/inertial coordinate frame
- Calculates/simulates stationkeeping maneuvers (repeat ground track mission - can include frozen orbit constraints)
- Tracks fuel expenditure

PLANETARY:

- Sun/Moon/planets positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue (FK5 - 1,812 stars)
- Planetary ephemeris origin: JPL DE-200
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Save to file/Print to laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/acceleration/mass/maneuvers/altitude/apogee/perigee/horizon interference
- Element set from propagator
- Element set by orbit determination from input/simulated observations
- Visibility azimuth/elevation/range/range-rate/topocentric right ascension and declination between site/satellite and satellite/satellite
- Sun rise/set times
- Lifetime analysis/re-entry predict (Allen-Eggars approximation)
- Object in sunlight

- Satellite heading N/S

ANALYSES:

- Comparison between orbit propagators

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by user defined (azimuth/elevation) profile

FEATURES:

- Early Orbit Determination module
- Can input constant state process noise (Qing) into Kalman and Extended Kalman filters
- Error analysis module
- Data management module
- Thruster models - Bipropellant and monopropellant

USERS:

- Charles Stark Draper Laboratory/Canadian RadarSat/USAF Phillips Laboratory

CONCERNS:

- Not a complete orbit analysis package
- Limited external distribution
- Requires external program for plotting

Dynamo

CONTACT:

MIT Lincoln Laboratory
Surveillance Techniques Group 91
244 Wood St.
Lexington, MA 02173-9108
(617) 981-3403
FAX: (617) 981-0991
Dr. E. Mike Gaposchkin
e-mail: gaposchkin@ll.mit.edu

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: TBD

SYSTEM REQUIREMENTS:

- Workstation

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Accuracy of 1 m

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Distance: kilometers (input)
- Angle: degrees (input)
- Time: days (input)
- Internal Units: seconds/centimeter/radian

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (output)
- Mean/Osculating Earth Centered Earth Fixed position and velocity (output)
- Osculating spherical (output) (topocentric for a specified site)

PROPAGATOR:

- Numerical propagator with Adams predictor-corrector integrator
- Can limit to two body
- Coordinate system: J2000.0/1950.0/satellite laser/WGS 84
- Maximum altitude = > 36,000 km
- Minimum altitude = < 500 km
- Can simulate rectilinear/parabolic/hyperbolic orbits

PERTURBATIONS:

- Geopotential: GEM-T3 (80x80)/
- Atmospheric drag: MSIS 1983 /CIRA 1986/Jacchia 1977 (corrected)
- Solar radiation pressure with spherical/cylindrical/conical shadow modeling and Rock IV Global Positioning System (GPS) flat plate elevation model
- Lunar/solar/n body effects
- Earth albedo/Earth tides (Wake)/ocean tides (JGM)/relativistic effects
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Weighted Least Squares/Kalman filter with parameter constraints
- Observation types: radar/SGLS/Laser ranging/telescope (angles only)/Global Positioning System (GPS)
- Measurements: (range/range-rate)/range difference/(azimuth/elevation)/(right ascension/declination)/interferometric
- Solve for parameters: geopotential/solar radiation pressure/atmospheric drag/station coordinates/Earth rotation/thrust/pass dependent (biases/refraction)

ORBIT MANEUVERS:

- Impulse/Finite burns

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Planetary ephemeris origin: JPL DE-200/USNO/Hill-Brown

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input observations

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package

Earth Satellite Program (ESP)

CONTACT:

The MITRE Corporation
Dr. Neal Hulkower
Burlington Rd
Bedford, MA 01730-0208
(617) 271-8917

- Comprehensive orbit mission analysis

PURCHASE INFORMATION:

- Cost: free
- Future developments: Source code may be released, multibeam/agile projections, sat-sat visibility, any Earth region, two-body option

SYSTEM REQUIREMENTS:

- Macintosh

SOFTWARE STRUCTURE/SUPPORT:

- Written in THINK PASCAL
- Documentation available with technical/user information
- Support group available
- Number of satellites limited to one in graphics- 200 in simulation
- Interfaces with external programs: to convert geosynchronous and ECI position and velocity vectors to Classical Keplerian (provided with software)

INPUT:

- GUI interactive menu/batch processing

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (output)

PROPAGATOR:

- Numerical propagator with Runge-Kutta 4th order integrator
- Can limit to two body

PERTURBATIONS:

- Geopotential: none/J2
- Atmospheric drag: US Standard 1976
- Solar radiation pressure
- Coriolis pseudoforces throughout trajectory (gives Vrel)

OUTPUT CONTENT:

- Element set from propagator
- Visibility elevation/range/range-rate between site/satellite
- Output can be limited to time of constraint satisfaction

ANALYSES:

- Multi-site/satellite simulation
- Ground coverage analysis

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation
- Elevation limits must be same for all ground sites

SENSOR OPTIONS:

- Define sensor cone with elevation (beamwidth)

- Set pointing constraints: aimed at point on Earth
- Can define multiple sensors per satellite
- Can define complex systems of constraints with (at least) between sites/satellites

GRAPHICS:

- Maps: zoomable/Mercator/ 3D perspective (spherical Earth)
- Ground track for one satellite

FEATURES:

- Outage zones for constellation coverage (up to 200 sats)
- Calculates single beam projection at several beam widths and labels the decibel loss at each contour
- Can display decibel loss at each contour for spot beam

CONCERNS:

- Requires external program to convert geosynchronous and ECI position and velocity vectors to Classical Keplerian (provided with software)

Edge

CONTACT:

Autometric Inc.
Frank Stampf
Lynn Mattie (Tech Dir.)
1330 Inverness Dr. Suite 350
Colorado Springs CO 80910
(719) 637-8332
FAX: (719) 637-8535
5301 Shawnee Rd
Alexandria, VA 22312-2333
(703) 658-4000

FEATURES:

- Combination of Omni and Wings
- Due out summer 1995

Eivan

CONTACT:

NASA-Ames Research Center
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #ARC-12365
email: service@cosmic.uga.edu

- Orbit mission analysis

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $50 & $12 for documentation

SYSTEM REQUIREMENTS:

- Macintosh

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (Microsoft® Excel worksheet/plot)
- Screen plot (2D lines/3D contours)

ORBIT MANEUVERS:

- Impulse burns
- Input thrust vector in spacecraft coordinate frame
- Pre-set burn times

ANALYSES:

- Proximity (< 1 km) operations between two vehicles

FEATURES:

- Can simulate up to 5 burns plots resulting trajectory with 20 points per burn

Element

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Orbit mission analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- CDC

OUTPUT CONTENT:

- Element set from propagator
- Sun rise/set times
- Lifetime analysis/re-entry predict
- Object in sunlight

CONCERNS:

- Not for external distribution
- Old program – replaced by MEANELT

EncounterVUE

CONTACT:

Doug Postman
(703) 506-5086
FAX: (703) 506-0179
GRC International, Incorporated
Decision Technologies Division
Marketing Department
1900 Gallows Road
Vienna, VA 22182
(703) 506-5000
FAX: (703) 506-0179
email: encountervue@grci.com

- Interactive tool for visualizing the operation of complex physical systems, including satellites, aircraft, ground vehicles, etc.

FEATURES:

- Allows user to visualize the operations of large systems, at the constellation, single platform, ground site, or subsystem level
- 2D and 3D displays
- May be tailored to include star catalogue, terrain, background imagery (satellite, aerial, etc.), and other data typically found in GIS applications
- Three dimensional and subsystem models are supported from a variety of modeling tools, including standard CAD software
- Graphical fidelity can be traded for program execution speed

Environment WorkBench (EWB)

CONTACT:

Maxwell Laboratory S^3 Division
Dr. Gary Jongward
PO BOX 1620
La Jolla, CA 92038-1620
(619) 587-7212
FAX: (619) 755-0474
Agnes Greb/John Lilley
2501 Yale Suite 300
Albuquerque, NM 87106
(505) 764-3164
FAX: (505) 843-7995

- Comprehensive orbit mission analysis and space environmental effects

PURCHASE INFORMATION:

- Cost: $1,500
- Future developments: possibly adding higher accuracy orbit propagator

SYSTEM REQUIREMENTS:

- PC/Macintosh/Sun/SGI workstation

SOFTWARE STRUCTURE/SUPPORT:

- Object oriented design
- Open structure - modifications easy/designed to be portable/
- Documentation available with technical/user information
- Support group available

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database
- Can accept propagator input from external program
- Database of sites/vehicles available with software
- Can save/load whole scenario/configuration
- Internal program written to accept NORAD catalog though disk/file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines/2D contours/3D contours)

ELEMENT TYPES:

- Mean Classical Keplerian (input/output)
- Mean Earth Centered Inertial position and velocity (input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Analytical propagator: Brouwer mean element

ORBIT MANEUVERS:

- Finite burns (electric propulsion)

OUTPUT CONTENT:

- Save to file/Print to color/laser printer (PostScript)
- Time history of latitude/longitude/equator crossing times
- Element set from propagator
- Visibility between site/satellite and satellite/satellite
- Output can be limited to time of constraint satisfaction

- Constraint satisfaction summary profile (average length/minimum length/maximum length/# occurrences/% time)
- Sun rise/set times

ANALYSES:

- Multi-site/vehicle/target simulation
- Monte Carlo dispersion analysis
- Ground coverage analysis
- Probability of collision
- Debris analysis

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation (min/max)/azimuth (min/max)/range (min/max)/user defined (azimuth/elevation) profile

SENSOR OPTIONS:

- Define sensor cone with elevation (min/max)/azimuth (min/max)/range (min/max)/antenna parameters
- Set pointing constraints: nadir pointing/fixed with respect to vehicle/fixed with respect to inertial frame
- Can define multiple sensors per site/vehicle
- Additional sensor patterns: square

GRAPHICS:

- Maps: zoomable/Mercator/ 3D perspective (spherical Earth)
- Maps show coastlines/islands/countries/states/lakes/rivers
- Ground/orbit tracks for all satellites
- Sensor ground swaths/instantaneous sensor footprint/Earth coverage contours
- Ground station coverage contours with general symbol ID
- Display solar terminator conditions
- 3D vehicle structure definition (satellite, rockets, space station databases) (can not accept other CAD/CAM definitions)

FEATURES:

- Designed to perform statistical analysis; the statistical module can be used to investigate how uncertainties propagate
- Solar array definition and analysis
- Natural space environment models (ambient neutral, ambient plasma, geomagnetic filed, meteors, debris, solar radiation, trapped particles, solar cycle, system generated environments)
- Space environment interactions with system (oxygen erosion, surface contamination and damage, atmospheric attenuation, solar cell collection, electric propulsion, optical contamination, radiation effects, structure transients, auroral charging, plasma contractors)

USERS:

- Used by Phillips Laboratory Geophysics Directorate, NASA/LeRC, NASA for international space station and for payload integration, SPEAR 3, SEPAC, TSS-1, CHAWS/WAKESHIELD, PASP+, PMG

EPSAT

CONTACT:

Maxwell Laboratory S^3 Division
Dr. Gary Jongward
PO BOX 1620
La Jolla, CA 92038-1620
(619) 587-7212
FAX: (619) 755-0474

- Comprehensive orbit mission analysis and space environmental effects

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Sun/SGI workstation

SOFTWARE STRUCTURE/SUPPORT:

- Object oriented design
- Open structure - modifications easy/designed to be portable/

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines/2D contours/3D contours)

ELEMENT TYPES:

- Mean Classical Keplerian (input/output)

PROPAGATOR:

- Analytical propagator: Brouwer mean element

OUTPUT CONTENT:

- Save to file/Print to color/laser printer (PostScript)

ANALYSES:

- Multi-site/vehicle/target simulation
- Monte Carlo dispersion analysis
- Probability of collision
- Debris analysis

GRAPHICS:

- 3D vehicle structure definition (can not accept other CAD/CAM definitions)

FEATURES:

- Natural space environment models (ambient neutral, ambient plasma, geomagnetic, meteors, debris, solar radiation, trapped particles, solar cycle)
- Space environment interactions with system (floating potentials, sheaths, ionization, Paschen breakdown, effluents, oxygen erosion, meteor and debris damage, column densities, sputtering)

CONCERNS:

- Static program - no plans to update/being absorbed in to another program (EWB)

Erdas

CONTACT:

ERDAS Inc.
2801 Buford Hwy., NE, Suite 300
Atlanta, GA 30329-2137
(404) 248-9000
Fax: (404) 248-9400

- Sensor analysis

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- PC- Microsoft® Windows™

GRAPHICS:

- Map shows Earth altitude through color (shaded relief)/3D perspective/surface generation/slope/aspect/contour
- Can display incoming satellite imagery data

FEATURES:

- Accepts image data and vector data (digitized screen data, annotations, ARC/INFO GENERATE/UNGENERATE formatted files, Digital feature analysis data, AutoCAD digital exchange files, & Stand interchange format)
- Rectification processing - ground control points, transformation order, resampling, map to map coordinate conversion, georeferencing
- Geographic information systems - data acquisition, extracting information, raster modeling
- Image resolution - broad term (# of pixels/display & area on ground/pixel), spectral (portion of electromagnetic spectrum recorded, course spectral resolution records a bandwidth, fine spectral resolution records a narrow bandwidth), spatial (measure of the smallest object that can be resolved), radiometric (measure of the dynamic range of the pixel value - # bits), temporal (measure of how often a sensor obtains imagery of the same area)

CONCERNS:

- Not a complete orbit analysis package
-

Flight Design System (FDS - Aerospace Corporation)

CONTACT:

The Aerospace Corp.
Larry Sharp
PO BOX 92957
Los Angeles CA 90245-2957

- Comprehensive orbit mission analysis

PURCHASE INFORMATION:

- Cost: free
- Future developments: FADS is classified SGI version

SYSTEM REQUIREMENTS:

- Perkin-Elmer (platform discontinued)
- Optional Macintosh terminal (input text files)
- Available off site capability: NASA VAX terminals/laser printer from CSOC with overnight tapes/modem

SOFTWARE STRUCTURE/SUPPORT:

- Written in Perkin-Elmer operating system language (difficult to port)

INPUT:

- Can load sites/vehicles/targets from modem

ORBIT MANEUVERS:

- Impulse/Finite burns
- Input thrust vector in spacecraft/inertial coordinate frame
- Simulates stationkeeping maneuvers

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (text)

SENSOR OPTIONS:

- Define sensor cone
- Set pointing constraints
- Can define multiple sensors per satellite

GRAPHICS:

- Maps: Mercator
- Maps show coastlines/islands/countries/states/lakes/rivers
- Print dot matrix printer
- Ground tracks for one satellite
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours with unique text ID

USERS:

- Shuttle mission planners

CONCERNS:

- Static program - no plans to update/being absorbed in to another program (FADS)
- No support group available (Barrios was on contract)

Flight Dynamics System (FDS - Telesat)

CONTACT:

Telesat Canada
1601 Telesat Court
Gloucester, Ontario
K1B 5P4 CANADA
Peter E Newman
(613) 748-0123
Internet: p.newman@telesat.ca
Frans C. Kes (Senior Mission analysis Specialist)
(613) 748-0123 x 2241
Internet: f.kes@telesat.ca
Fax: (613) 748-8925

- Determine, predict, and control orbit and spin axes of GEO and GEO transfer satellites in fuel efficient manner

PURCHASE INFORMATION:

- Cost: $400,000
- Cost to non-government: $425,000 (for GEO + GEO transfer)
- Future developments (Summer, 1996): obtaining ISO 9000 certification, support all orbit altitudes, drag, an internal reference frame (J2000) that will be internal to the integrator, and conversion between UTC and UT1, orbit inputs/outputs will be permitted in the true equator/equinox of date reference frame, and equinoctial elements will also be added
- Purchase includes: 2 HP Apollo 712/60 color workstations, 1HP LaserJet 4+ B/W printer, 1 HP Deskjet 1200C color printer, 1 HP router, comprehensive training at Telesat headquarters (4 weeks + 2 weeks for Transfer option), 1 Theory manual, 2 sets of users guides, 1 maintenance manual, 2 licenses to use, 6 month warranty support (additional workstations can be added if licensed, each additional license includes user guide)
- Purchase options: GEO only/GEO + GEO transfer/Data Management Subsystem option - 2 external 1.2 Gb hard disks

SYSTEM REQUIREMENTS:

- HP-Apollo 700
- DEC Alpha being developed
- Operating system: HP UX
- RAM: 64 MB
- Hard Drive Space: Source Code - 400 MB; Executable - 50 MB; Data files - 50 MB
- Media Format: FTP/DSS Tapes

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 90/C++ with double precision
- X-FACE/MOTIF used for GUI
- Open structure - modifications easy/supports multiple networked users
- Source code available (purchase option)
- Documentation available with technical/user information
- Software verified against older version of FDS which was validated against USAF at Sunnyvale for Skynet 4 program (Oakhanger, UK)
- Support group available (on-site and extended warranties available)
- On-line help
- Automatic run at predetermined times of external/internal programs

INPUT:

- GUI interactive menu
- Database of sites/satellites available with software (HS-376, HS-601, MM5000, and Space Bus 100/300) (public/private database setup)
- Input error checking (limits of values)

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time (1 operator manages up to 4 satellites)
- Run-time errors allow escape back to program with inputs intact

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines - can plot multiple variables on same plot)
- Curve-fitting tool (polynomial, Fourier series, exponential, general regression, spectral analysis)

CONVERSION/TRANSFER:

- Converts between UTC-UT1 (Summer, 1996)

UNITS:

- Time: Calendar date/Hours (local)/Minutes/Seconds/UTC
- Longitude convention set to positive for East/Longitude convention set to positive for West

ELEMENT TYPES:

- Mean Classical Keplerian (input/output) (GEO output only)
- Osculating equinoctial (input/output) (Summer, 1996)
- Osculating Earth Centered Inertial position and velocity (FK5) (input/output)

PROPAGATOR:

- Numerical Enke propagator with Runge-Kutta 4th order/Gauss-Jackson 10th order integrator with variable step size
- Analytical propagator: KAMEL (for GEO only)
- Can limit to two body (Enke)
- Can propagate forward/backward in time through integration
- Coordinate system: Earth (true equator mean equinox of date)/(mean equator mean equinox of 1JAN2000.00:00:00 or 1JAN1950.00:00:00)/ (true equator true equinox of date - Summer, 1996) (input/output); mean equator mean equinox of 1JAN2000.00:00:00 (internal)
- Tabular/graphical close approach determination (up to 10 geosynchronous satellites)
- Maximum altitude = >36,000 km (super-synchronous)
- Minimum altitude = 5,000-20,000 km (500-1,000 km in Summer, 1996)

PERTURBATIONS:

- Geopotential: none/GEM-10 30x30
- Atmospheric drag (Summer, 1996)
- Solar radiation pressure (file based - accounts for solar array pointing offsets)
- Analytically propagated/Chebyshev/quartic interpolated lunar/solar/n body effects
- Spacecraft modeling: mass/drag coefficient (Summer, 1996)/cross-sectional area
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Weighted Least Squares/Kalman filter with parameter constraints (Kalman does orbit and attitude determination simultaneously)
- Manual/automatic smoothing/culling of incoming data
- Observation types: radar/SGLS/Laser ranging
- Measurements: (range/range-rate)/(azimuth/elevation)
- Solve for parameters: solar radiation pressure (torque model)/pass dependent (range biases)/residuals (model includes systematic errors and plant noise)
- Orbit determination automatically informed of planned maneuvers
- Real-time/batch orbit determination

ATTITUDE DETERMINATION:

- Weighted Least Squares/Kalman filter

- Real-time/batch modes
- Spin stabilized modeled

BALLISTIC/LAUNCH TRAJECTORY:

- Launch window analysis: determined opportunities to reach specified orbit from specified launch site
- Launch constraints: lighting conditions (noon/midnight)/spin axis and sun angle/sensor interference with sun/attitude determination cutouts

ORBIT MANEUVERS:

- Impulse/Finite burns
- Calculates/simulates stationkeeping maneuvers
- Stationkeeping constraints: North-South/East-West/Spin axis
- Overrides on computed maneuvers to satisfy special requirements
- Calculates time of flight and velocity needed for Hohmann transfer between two orbits (optimizes remaining orbital boost maneuvers - firing time and attitude and optionally the Delta V - produces sensitivity tables and graphs of orbit and fuel usage versus maneuver parameters)
- Pre-set burn
- Real-time calculation
- Can optimize for fuel efficiency
- Tracks fuel expenditure
- Estimate thruster performance/trend information

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue
- Planetary ephemeris origin: JPL DE-200

OUTPUT CONTENT:

- Save to file/Print to color/laser printer/rescalable chart recorder with up to 6 channels and 4 pens each
- Time history of maneuvers
- Element set from propagator
- Element set by orbit determination from input observations
- Visibility azimuth/elevation/polynomials between site/satellite

ANALYSES:

- Multi-site/satellite simulation
- Monte Carlo dispersion analysis/graphics show probability distributions

GROUND SITES:

- Defined by latitude/longitude/altitude

SENSOR OPTIONS:

- Additional sensor patterns: diamond shaped telescopes

GRAPHICS:

- Maps: zoomable/Mercator/North Pole view/point interrogation
- Save to file/Print to color/laser printer/rescalable chart recorder with up to 6 channels and 4 pens each
- Ground tracks for all satellites with unique text ID
- Instantaneous sensor footprint/omni-antenna signal strengths from visible regions
- Ground station coverage contours
- Display solar terminator conditions

FEATURES:

- Participated in Orbit Propagator Software Survey
- Graphic timeline/schedule of activities/events
- For GEO transfer, filter can track and steer large attitude slews, and the weighted least squares can additionally solve for Earth-Sensors chord width biases
- Ephemeris generation tools: static antenna angle prediction tool, multibody shadowing/transit/earth-sensor interference/cluster separation prediction, real-time/file transfer antenna drive

- Fuel lifetime prediction tool estimates when fuel will run out - extrapolates from past experience, thruster modeled in database, actual thruster history, stationkeeping maneuvers required before end-of-life, planned satellite relocation, inclined orbit, and de-orbiting maneuvers
- Stationkeeping history plotting tool plots long-term achieved longitude, inclination, and attitude motion
- GEO transfer - ground station visibility plots, timeline of dynamics-related events with real-time network-smart display, trajectory design and dispersion analysis tools plan all maneuvers to place a newly launched satellite on station
- GEO transfer maneuver planning - attitude slews and spin-adjust maneuvers for spinning satellites, apogee and perigee burns (multi fire liquid or single fire solid fuel), station acquisition maneuvers, produces maneuver messages, update the event list, and track fuel usage, user interface allows setting orbit/attitude constraints
- Attitude slew: optimally planned to the target (spinning) attitude for orbit adjustment or signal optimization, etc.
- Momentum Control: prepares for spin-change adjustment

USERS:

- Deutsche Telekom (4 GEO), UK Ministry of Defense (Skynet 4 support), Satellite Business Systems (5 GEO), Telesat (6 GEO)

CONCERNS:

- Not a complete orbit analysis package (currently for GEO/GEO transfer only)

Force Management System (FMS)

CONTACT:

ARINC Inc.
1925 Aerotech Dr. Suite 212
Colorado Springs, CO 80916
Jesus Borrego
(719) 574-9001

- Define strategic (static, seldom changing) and tactical (dynamic) communication networks

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC with Microsoft® Windows™

SOFTWARE STRUCTURE/SUPPORT:

- Written in SQL database management system
- On-line help
- Interfaces with external programs: Satellite Management System, Satellite Planning Decision Support System, Satellite Coverage Model, Operational Reporting and Management System, System Effectiveness Model, and Planning Analysis and Management System

INPUT:

- GUI interactive menu
- Can load sites/satellites from database

OUTPUT CONTENT:

- Save to file/Print to laser printer

GROUND SITES:

- Defined by latitude/longitude/altitude

GRAPHICS:

- Maps: zoomable/Mercator/point interrogation
- Ground tracks for all satellites
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours

FEATURES:

- Password protection
- Define ground site subsystems and components at successive levels of detail and view status at each level
- Determine the operational status of ground sites from roll-up of status of individual components
- Designate primary, secondary, and tertiary control assignments between ground sites and satellites and display the assignments graphically on map
- Sites and satellites are color coded to indicate operational status
- Add, move, or delete ground sites and satellites with mouse

USERS:

- US Army Space Command to assess status and operate DSCS

CONCERNS:

- Never developed beyond version 1
- Not a complete orbit analysis package - can be with interface programs
- Never developed past version 1

Forest and Trees

CONTACT:

Channel Computing
53 Main St.
Newmarket NH 03857
FAX: (603) 659-7590

- Data access and reporting tool can be used as timeliner

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- PC with Microsoft® Windows™

SOFTWARE STRUCTURE/SUPPORT:

- Interfaces with external programs: DataEase, dBase, Excel, Lotus, Paradox, Q&A, R:Base

FEATURES:

- Timeline/schedule of activities/events

CONCERNS:

- Not a complete orbit analysis package
- Not specifically developed for orbit analysis applications

Goddard Mission Analysis System (GEMAS)

CONTACT:

NASA Goddard Spaceflight Center
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #GSC-12392
email: service@cosmic.uga.edu

- General control framework for multiple applications

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $5,000 + $220 documentation

SYSTEM REQUIREMENTS:

- IBM 370/IBM 3250/2250

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN/JCL/Assembler
- Documentation available

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines)

PERTURBATIONS:

- Lunar/solar/n body effects

ORBIT MANEUVERS:

- Impulse burns

PLANETARY:

- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input/simulated observations
- Visibility azimuth/elevation between site/satellite

ANALYSES:

- Monte Carlo dispersion analysis
- Optimization through iteration
- Ground coverage analysis

GROUND SITES:

- Defined by latitude/longitude/altitude

GRAPHICS:

- Maps: Mercator

FEATURES:

- Over 600 orbit routines controlling Spacecraft altitude, thrust effects on spacecraft, developing maneuver commands for hydrazine thruster
- Executive Load Module: interprets user control directions and data management, passes control to user designated dynamic load modules after preparing user specified and default utility data
- Dynamic Load Module: contains application software - routine libraries, data transformed though analysis
- Automatic Sequencer: user control of other 3 components, in special GAMS language

GEMASS

CONTACT:

Capt Kieth Longstreth
(617) 377-3148

- 6 DOF launch ascent trajectory program

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC

BALLISTIC/LAUNCH TRAJECTORY:

- 6DOF trajectory simulation and optimization

CONCERNS:

- Not a complete orbit analysis package

GEODYN

CONTACT:

NASA Goddard Spaceflight Center
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #GSC-12014
email: service@cosmic.uga.edu

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $197 documentation

SYSTEM REQUIREMENTS:

- IBM 370 and CDC Cyber 205

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN IV/Assembler for IBM 370 and all FORTRAN for Cyber 205

PROPAGATOR:

- Numerical Cowell predictor-corrector integrator (equations of motion) and predictor only for variation of partials

PERTURBATIONS:

- Atmospheric drag: MSIS 1986/Jacchia 1971

ORBIT DETERMINATION:

- Estimation: Bayesian Least Squares
- Automatic smoothing of incoming data
- Solve for parameters: data error correction/residuals
- Requires a priori data for all estimates and uncertainties of all parameters

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input observations

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Partitioned solution allows unlimited solution arcs

CONCERNS:

- Not a complete orbit analysis package

GEOSAT

CONTACT:

Norwegian Defense Research Establishment
PO BOX 25
N-2007 Kjeller, Norway
Dr. Per Helge Anderson
+47 63 80 74 07
FAX: +47 63 80 7212
email: per-helge.anderson@ffi.no

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: free
- Future developments: user manual (1998-1999), addition of IFSAR and gradiometry measurement types

SYSTEM REQUIREMENTS:

- Operating system: UNIX
- RAM: 32 MB
- Hard Drive Space: Source Code - 5 MB; Executable - 50 MB; Data files ≈ 1 GB
- Media Format: FTP/data tapes/CD-ROM

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Open structure - modifications easy/designed to be portable/
- Documentation available with technical information (Complete user manual in 1998-1999)
- Software verified against operational satellite data by author (VLBI/GPS/SLR: LAGEOS I & II, Etalon I & II, Meteor-3, ERS-1 & 2, TOPEX; PRARE: Meteor-3, ERS-2; DORIS: TOPEX; Doppler: ARGOS, SARSAT/COSPAS)
- Number of sites/satellites limited only by memory

INPUT:

- GUI interactive menu

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Distance: meters
- Angle: degree
- Time: Seconds (TDT/TDB/UTC)
- Internal Units: seconds (TDT/TDB); meters; Radians

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating Modified Keplerian (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (input/output)

PROPAGATOR:

- Numerical Cowell/Enke propagator with self-starting Gauss-Jackson
- Analytical propagator: Aksnes 1st and 2nd order theory
- Can limit to two body
- Coordinate system: Earth mean equator mean equinox of 1JAN2000.00:00:00 (input/output/internal); can also have solar barycentric reference frame
- Maximum altitude = > 36,000 km
- Minimum altitude = 200 km

PERTURBATIONS:

- Geopotential: none/GEM-10B/GEM-L2/GEM-T1/GEM-T2/GEM-T3/JGM-3 (70x70)
- Atmospheric drag: DTM 1977/MSIS 1987 /Jacchia 1977
- Solar radiation pressure with cylindrical/conical shadow modeling
- Chebyshev interpolated lunar/solar/n body effects
- Earth albedo/JGM 3 Earth/ocean tides/relativistic effects
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas

ORBIT DETERMINATION:

- Estimation: Bayesian Least Squares/Kalman filter
- Manual/automatic smoothing/culling of incoming data
- Observation types: radar/laser ranging/Global Positioning System (GPS)/very long baseline interferometry/PRARE/XALT/Ephemeris/DORIS/WVR/satellite-satellite tracking (SST)
- Measurements: (range/range-rate)/range difference/(azimuth/elevation)/(right ascension/declination)/interferometric
- Solve for parameters: geopotential/solar radiation pressure/atmospheric drag/station coordinates and velocities/Earth rotation/pass dependent (range biases/refraction/clock errors)/data error correction (white or colored noise, or random walk)/residuals/radio source positions/universal time (UT1)/polar motion/nutation/precession/solid Earth tidal parameters/ocean tidal amplitudes and phases/tidal variations in Earth orientation/tidal variations in geocenter/satellite dynamic scaling parameters/general relativity parameters/tropospheric zenith delay
- Batch orbit determination

PLANETARY:

- Planetary ephemerides in position and velocity
- Planetary ephemeris origin: JPL LEDE 200

OUTPUT CONTENT:

- Save to file/Print to laser printer
- Element set from propagator
- Element set by orbit determination from input/simulated observations

ANALYSES:

- Multi-site/vehicle/target simulation

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Participated in Orbit Propagator Software Survey
- Software runs in estimation mode, simulation mode, or error analysis mode
- Uniqueness is can handle satellite tracking and VLBI data in one program for simultaneous solution for maximum information extraction from the data

CONCERNS:

- Not a complete orbit analysis package
- Limited external distribution (only Norwegian Universities so far)

GEOSYN

CONTACT:

Dr. C. Chao
The Aerospace Corporation
PO BOX 92957
M4/948
Los Angeles, CA 90009-2957
(310) 336-4295
FAX: (310) 336-5827
e-mail: chao@courier2.aero.org

- Geosynchronous orbit simulation

PURCHASE INFORMATION:

- Cost: $50-$100
- All users must be supporting government contracts

SYSTEM REQUIREMENTS:

- PC
- Hard Drive Space: Executable - 400 KB
- Media Format: Disk

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 in double precision
- Documentation available with technical/user information
- Software verified against TRACE and actual GEO ephemerides by the Aerospace Corp.

INPUT:

- GUI interactive menu/batch processing

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: meters
- Angle: degree
- Time: Calendar date/Hours (GMT or local)/Minutes/Seconds/ GMT
- Internal Units: Julian Date/meters/radians

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating equinoctial (output)

PROPAGATOR:

- Analytical propagator: mean propagator specifically tailored for geosynchronous orbits
- Coordinate system: Earth true equator true equinox of 1JAN2000.00:00:00 (input) and of date (output)
- Maximum altitude = 38,000 km
- Minimum altitude = 34,000 km

PERTURBATIONS:

- Geopotential: WGS-84 (6x6)
- Solar radiation pressure with conical shadow modeling
- Lunar/solar body effects
- Spacecraft modeling: mass/coefficient of reflectivity/cross-sectional area
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns

- Calculates/simulates stationkeeping maneuvers (longitude/inclination/argument of perigee/eccentricity)
- Stationkeeping constraints: North-South/East-West

PLANETARY:

- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Element set from propagator
- Visibility range/range-rate between site/satellite

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package

GTARG

CONTACT:

NASA Center for Aerospace Information
Manager Technology Transfer Office
800 Elkridge Landing Rd
Linthicum Heights, MD 21090-9908
TSP # 233
Written by Bruce Shapiro, Caltech & JPL
NASA
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #NPO-19257
email: service@cosmic.uga.edu

- Special purpose maneuver planning tool

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $600 + $21 documentation

SYSTEM REQUIREMENTS:

- DEC VAX
- Operating system: VMS
- Media Format: TK50 tape cartridge/9-track magnetic tape (both in DEC VAX BACKUP format)

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Interfaces with external programs: EZPLOT/PGPLOT

INPUT:

- Namelist-like input (EZPLOT)

RUN-TIME OPTIONS:

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PROPAGATOR:

- Analytical propagator (mean)

PERTURBATIONS:

- Geopotential: Merino's extension of Grove's theory
- Atmospheric drag: Jacchia-Roberts
- Kaula lunar/solar body effects
- Spacecraft modeling: cross-sectional area (variable mean area)
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns
- Calculates/simulates stationkeeping maneuvers (maintain repeat ground track within 1 km for repeat period of 9.9 days)

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input/simulated observations

FEATURES:

- Runout mode allows ground-track propagation without targeting

- Maneuvers are targeted to maintain precisely either the ground track or a three standard deviation error envelope about the ground track.
- Can either maximize time between maneuvers or force control band exit to occur at specified intervals (for next burn time)
- Models of errors include: uncertainties in orbit determination, errors in execution of maneuvers, unpredictability of drag, use of knowledge of fixed forces along trajectory

USERS:

- Topex/Poseidon Ground Track Maintenance Maneuver Targeting Program

CONCERNS:

- Not a complete orbit analysis package
- Requires external program for plotting (PGPLOT - available on Caltech web)
- Requires external program for input (EZPLOT - included with software)

Generalized Trajectory Simulation (GTS)

CONTACT:

The Aerospace Corp.
PO Box 92957
MS M4/941
Los Angeles CA 90009
Greg Fruth
(310) 336-4287
E-mail: fruth@canal.aero.org

- High accuracy propagation and orbit determination

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PA-RISC (HP 9000 series workstation)
- Operating system: HP UX 9.01 or higher
- RAM: 64 MB
- Hard Drive Space: Source Code - 42 MB; Executable - 32 MB; Data files - 100 KB
- Media Format: FTP/DSS Tapes

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/C/C++with double precision
- Open structure - modifications easy (can add any FORTRAN/C routine to calculate appropriate physical effect)
- Software verified against POST, TRACE, and 25 years experience
- Number of satellites limited to one per simulation

INPUT:

- GUI interactive menu

UNITS:

- Distance: feet/nautical miles
- Angle: degree
- Time: Hours/Minutes/Seconds
- Internal Units: second/feet/radian

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)

PROPAGATOR:

- Numerical propagator with Runge-Kutta 4th order/Adams-Moulton 4-8th order with fixed and variable step size
- Analytical propagator: two body + J2
- Can limit to two body
- Maximum altitude = >36,000 km
- Minimum altitude = 0 km
- Can simulate rectilinear/parabolic/hyperbolic orbits

PERTURBATIONS:

- Geopotential: user supplied (up to 12x12)
- Atmospheric drag: MSIS 1983/US Standard 1962/user defined atmospheric table or subroutine
- Central body replacement for extra-terrestrial orbits

- Spacecraft modeling: mass/drag coefficient/cross-sectional area/can separate satellite into main body and panel component areas
- Engine thrusters

ORBIT MANEUVERS:

- Impulse/Finite burns

PLANETARY:

- Allows replacement of central body with user identified planet for orbit simulation

FEATURES:

- Participated in Orbit Propagator Software Survey
- Different coordinate systems: Body/ECI/ECEF/LCI/LCID/LH/LHG/MAG/VA/VI

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution
- No user documentation
- Number of satellites limited to one per simulation

GLIMPSE

CONTACT:

The Aerospace Corporation
Chris Kobel
(310) 336-7861
Tom Lang
(310) 336-4307
PO Box 92957
Los Angeles CA 90245-2957

- Computes coverage and revisit characteristics and displays them in color contour form on a world map

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- SUN workstation

ANALYSES:

- Ground coverage analysis

FEATURES:

- Incorporates Crane rain model to perform link margin calculations for MILSATCOM architectures

CONCERNS:

- Not a complete orbit analysis package

HEOGEN

CONTACT:

Dr. C. C. Chao
The Aerospace Corporation
PO BOX 92957
M4/948
Los Angeles, CA 90009-2957
(310) 336-4295
FAX: (310) 336-5827
e-mail: chao@courier2.aero.org

- High eccentricity (Molniya) orbit propagator

PURCHASE INFORMATION:

- Cost: $50-$100
- All users must be supporting government contracts

SYSTEM REQUIREMENTS:

- PC
- Hard Drive Space: Executable - 350 KB
- Media Format: Disk

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 in double precision
- Documentation available with technical information
- Software verified against TRACE by the Aerospace Corp.

INPUT:

- GUI interactive menu/batch processing

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: meters
- Angle: degree
- Time: Calendar date/Hours (GMT or local)/Minutes/Seconds/ GMT
- Internal Units: Julian Date/meters/radians

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)

PROPAGATOR:

- Semi-analytic mean propagator (tailored for high eccentricity orbits)
- Coordinate system: Earth true equator true equinox of 1JAN2000.00:00:00 (input) and of date (output)

PERTURBATIONS:

- Geopotential: WGS-84 (9x9)
- Atmospheric drag: MSIS 1990 E/Jacchia 1971
- Solar radiation pressure with cylindrical shadow modeling
- Lunar/solar body effects
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/can separate satellite into main body and panel component areas
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns
- Calculates/simulates stationkeeping maneuvers (longitude)

PLANETARY:

- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Element set from propagator
- Visibility range/range-rate between site/satellite

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package

High Precision Orbit Propagator

CONTACT:

Microcosm Inc.
2377 Crenshaw Blvd., Suite 300
Torrence, CA 90501
(310) 320-0555
FAX: (310) 320-0252
E-mail: softsmad@aol.com
http://www.sblink.com/microcosm

- High accuracy propagation

PURCHASE INFORMATION:

- Cost: $950 (standalone)
- Cost: $2,200 (Satellite Tool Kit module)
- Annual Maintenance: $330

SYSTEM REQUIREMENTS:

- Sun Sparc/Intel 80486 + Pentium PC
- Operating system: SUN UNIX/Microsoft® Windows™ 95
- RAM: 640 KB
- Hard Drive Space: Source Code - 388 KB; Executable - 120 KB; Data files - 932 KB
- Media Format: Disks

SOFTWARE STRUCTURE/SUPPORT:

- Written in C with double precision
- Documentation available with technical/user information
- Software verified with analytic benchmarks and sun/moon ephemeris verified against Astronomical Almanac by Leo W Early Jr.
- Interfaces with external programs: Satellite Tool Kit (special purchase)
- Accuracy of 12 m or better per orbit (designed for short propagation periods)

INPUT:

- Column formatted file

UNITS:

- Distance: meters (input/output)
- Time: Calendar date/Minutes/Seconds/UTC (input/output)
- Internal Units: seconds from epoch/meters/radian

ELEMENT TYPES:

- Osculating Earth Centered Inertial position and velocity (FK5) (input/output)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta-Fehlberg 7-8th order with variable step size
- Can propagate forward/backward in time
- Coordinate system: Earth mean equator mean equinox of 1JAN2000.00:00:00 (input/output/internal) (can have Earth fixed coordinate system for evaluating perturbations)
- Maximum altitude = 0.1 AU
- Minimum altitude = 10 km
- Can simulate rectilinear/parabolic/hyperbolic orbits

PERTURBATIONS:

- Geopotential: JGM-2 (70x70) - user can truncate
- Atmospheric drag: Time varying Harris-Priester (modified to include Diurnal bulge)
- Solar radiation pressure with cylindrical shadow modeling
- Chebyshev lunar/solar body effects

- Precession/nutation/delta UT1 and TAI and TDT/diurnal rotation/Barycentric displacement
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area

OUTPUT CONTENT:

- Element set from propagator

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package (can be with ties to Satellite Tool Kit)

IGOS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Launch window analysis program

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- VAX

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution
- Software no longer in service – SOAP performs similar analyses

IMPACT

CONTACT:

The Aerospace Corporation
Marlon Sorge
(505) 846-2790
PO Box 92957
Los Angeles CA 90245-2957

- Generates fragment distributions from on-orbit collisions or explosions.

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- Available on SUN workstations

FEATURES:

- Data can directly feed DEBRIS

CONCERNS:

- Not a complete orbit analysis package

Integrated Mission Program (IMP)

CONTACT:

NASA Marshall Space Flight Center
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #MFS-28606
email: service@cosmic.uga.edu

- Simulation Language for Earth/Moon/Mars and other planet missions

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $2,000 + $74 documentation

SYSTEM REQUIREMENTS:

- DEC VAX
- Operating system: VMS

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Documentation available with technical/user information
- Interfaces with external programs: TEKPLOT

INPUT:

- Column formatted file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (TEKPLOT)

UNITS:

- Distance: meters
- Mass: Lb.

PROPAGATOR:

- Numerical propagator with Runge-Kutta-Fehlberg 7th order with variable step size
- Can limit to two body

PERTURBATIONS:

- Geopotential: none/J2/J3
- Atmospheric drag
- Mars Atmospheric models
- Solar radiation pressure
- Lunar/solar body effects
- Central body replacement for extra-terrestrial orbits
- Engine thrusters

ORBIT DETERMINATION:

- Determines velocity needed to rendezvous target
- Can optimize for fuel efficiency

ORBIT MANEUVERS:

- Impulse/Finite burns

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Interplanetary targeting
- Allows replacement of central body with user identified planet for orbit simulation

FEATURES:

- Large event/maneuver menu
- Line of sight communication guidelines, propulsion system choices, Earth/Mars soft landing
- Optimal thrust guidance parameters calculated

CONCERNS:

- Number of satellites limited (3 - main, targeter, observer)
- Requires external program for plotting (TEKPLOT - included with purchase)

Initial Space Safety System (ISSS)

CONTACT:

Logicon Ultrasystems, Inc.
1350 Villa St.
Mountain View, CA 94041
Mr. Nicholas Chiochios
(415) 965-7190, ext. 374

- Space/space-related safety tests and hazard evaluation for satellite inter-range operations

PURCHASE INFORMATION:

- Cost: free
- Future developments: Include more hazards (radio frequency interference, directed energy/laser, expanded debris modeling, reentry/decay, reentry breakup, expanded report generation, graphics output)

SYSTEM REQUIREMENTS:

- Sun SPARC 10

SOFTWARE STRUCTURE/SUPPORT:

- Written in C/Ada
- X-Windows/used for GUI
- Open structure - designed to be portable/supports multiple networked users
- Interfaces with external programs: OAWS)(first part to replace AFSCN command and control segment)

INPUT:

- GUI interactive menu/batch processing
- Element set only through track tape of whole satellite catalog

OUTPUT FORMAT:

- ASCII/text data

ELEMENT TYPES:

- Mean NORAD 2-line element set

PROPAGATOR:

- Orbit propagator: ATA Variable Force Model

OUTPUT CONTENT:

- Save to file/Print to color/laser printer

ANALYSES:

- Probability of collision
- Debris analysis

FEATURES:

- Purpose to decrease inter-range operations activities (i.e. collision avoidance) from 8 hr. to 20 min for 6000 satellites or less; more satellites will take 30-40 min longer (done in batches rather than serially)
- Orbit engineering planning, operational support, satellite test, post-test analysis with hazard evaluation applications
- Integrated Hazard Evaluation (IHE) - considers all hazards as black box holding any given set of applications/models for operational access

USERS:

- Air Force Satellite Control Network (AFSCN)

CONCERNS:

- Not a complete orbit analysis package

INSTATRAK

CONTACT:

Paul Williamson (Developer), HAM KB5MU
Capt Kieth Longstreth
(617) 377-3148

- General purpose mission analysis

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Open structure - modifications easy/designed to be portable
- Source/object code available

INPUT:

- Can load satellites from modem/Internet

RUN-TIME OPTIONS:

- Real-time data processing

OUTPUT CONTENT:

- Visibility azimuth/elevation/range/range-rate between site/satellite

FEATURES:

- Can control antenna with angles to rotor driver
- Can control radio driver with range/range-rate

USERS:

- HAM radio operators

CONCERNS:

- Not a complete orbit analysis package
- Number of satellites limited (1)

Integrated Debris Evolution Suite (IDES)

CONTACT:

Walker, S. Hauptmann, R. Crowther, H. Stokes, A. Cant
Space Department
Defense Research Agency
Farnborough
Hants.
GU14 6TD
United Kingdom

- Debris analysis

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- Any UNIX workstation
- Operating system: X-Windows

SOFTWARE STRUCTURE/SUPPORT:

- Software verified against reliable measurement data (USSPACECOM catalog flux, Haystack radar flux, and LDEF returned surface flux)

INPUT:

- GUI interactive menu/batch processing
- Column formatted file

OUTPUT FORMAT:

- ASCII/text data

PROPAGATOR:

- Analytical propagator (mean: time step = 1 month)
- Can propagate forward/backward in time

PERTURBATIONS:

- Geopotential: J2/J3
- Atmospheric drag: CIRA 1972
- Solar radiation pressure
- Lunar/solar body effects

ANALYSES:

- Monte Carlo dispersion analysis (collision risk with smaller mass debris and individual risk assessment with large objects)
- Probability/lethality of collision (launch, explosion, de-orbit rates, and constellation architectures)
- Debris analysis

FEATURES:

- Simulates past environments, correlated with measurements, and provides more confident predictions of current and future events
- Results provided for particles with sizes down to 10 microns
- Models not only fragmentation but includes secondary ejecta, paint flakes from debris/meteoroid impact on satellite population
- Simulation provides 'snapshots' of LEO flux environment to model collision evolution and facilitate directional collision risk analysis
- Systems can be added to simulation to analyze long-term impact on debris environment

CONCERNS:

- Not a complete orbit analysis package

Integrated System Manager (ISM)

CONTACT:

ARINC Inc.
11770 E Warner Ave., Suite 210
Fountain Valley, CA 92708
Ron Watt

- Manages remote assets - integrated network platform with application programs

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- UNIX workstation

SOFTWARE STRUCTURE/SUPPORT:

- Object oriented design
- Open structure - modifications easy/designed to be portable/supports multiple networked users

FEATURES:

- Provides operations manager greater control and flexibility to respond to changing system status and customer requirements
- Software Bus: manages information for access by all workstations (including customers) - based on open systems standards - easy to expand
- Applications: library of applications provide status, control, tracking, and information access and fusion functions
- Communications Infrastructure: uses existing and developing communications systems - facilitates local/regional connections (wireless/cellular/private) including INMARSAT/ORBCOM/IRIDIUM - unique transaction model reduces communication traffic and cost by acquiring only the information needed
- Intersystem Gateway: pulls information from existing databases to ISM client-server for operational use - electronic interfaces to export information
- Remote Unit: Makes most of existing equipment and integrates new to enhance data collection, positioning, and commanding capabilities
- Any parameter of interest can be monitored by operator or customer
- Can issue commands to remote units across the same communication links used to retrieve information
- ISM manages events recognized and tracked by system - pending late shipment alert, temperature alarm, equipment failure, etc.
- Provides remote equipment health monitoring and fault diagnostics to reduce equipment downtime and to increase maintenance efficiency

CONCERNS:

- Not a complete orbit analysis package

Inertial Upper Stage Spin Simulation (IUS/SPINSIM)

CONTACT:

NASA Marshall Space Flight Center
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
Cosmic Order #MFS-28811
email: service@cosmic.uga.edu

- Evaluates spinning stage with fixed burn motor

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $800 + $17 documentation

SYSTEM REQUIREMENTS:

- DEC VAX
- Operating system: VMS

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Documentation available

INPUT:

- Column formatted file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PROPAGATOR:

- Numerical Runge-Kutta 4th order integrator

PERTURBATIONS:

- Geopotential: J2
- Vehicle attitude: 6DOF/rotational dynamics (through quaternions)/moments of inertia/cross products of inertia/time derivative of inertia/torque/solid thrust build up/changing mass/center of gravity

BALLISTIC/LAUNCH TRAJECTORY:

- 6DOF trajectory simulation
- Customize up to 1 burn stage with 2 coast phases

FEATURES:

- Simulates Spinning 3rd stage for IUS of Jupiter mission

CONCERNS:

- Not a complete orbit analysis package
- Requires external program for plotting

KRONOS

CONTACT:

Honeywell Systems and Research Center
Mark Boddy
3660 Technology Dr.
Minneapolis, MN 55418
(612) 951-7403
FAX: (612) 951-7438

- Scheduling/timeline

PURCHASE INFORMATION:

- Cost: unknown

SYSTEM REQUIREMENTS:

- UNIX workstation

INPUT:

- GUI interactive menu/batch processing

FEATURES:

- Graphic timeline/schedule of activities/events
- Based on time map manager
- Supports scheduling with state changes, inter-activity constraints, and complex resource interactions
- Schedules constructed incrementally
- Maintains activity window and duration bounds rather than requiring them to be precisely specified
- Binds/unbinds activities to specified resources
- Identifying and resolving resource conflicts
- Not sure if orbit dynamic effects on schedule are computed or input from external programs (ground station contact, eclipse, etc.)

CONCERNS:

- Not a complete orbit analysis package

KSAT

CONTACT:

Kaman Sciences Corporation
PO Box 7463
Colorado Springs CO 80933-7463
Ken Kopke
(719) 591-3672

- Comprehensive orbit mission analysis

PURCHASE INFORMATION:

- Cost: $5,000
- Future developments: have code to do more - can add at user request

SYSTEM REQUIREMENTS:

- SGI workstation

SOFTWARE STRUCTURE/SUPPORT:

- Open structure - modifications easy
- On-line help
- Number of sites/satellites limited only by memory
- Software origin from: Government versions is Satellite and Missile Analysis Tool (SMAT)

INPUT:

- GUI interactive menu
- Can load sites/satellites/sensors from database
- Database of satellites/sensors available with software (whole NORAD unclassified catalog)
- Can save/load whole scenario/configuration
- Internal program written to accept NORAD catalog though file
- Constellation input (load element sets by constellation name, or by country)

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

CONVERSION/TRANSFER:

UNITS:

- Distance: kilometers (input/output)
- Angle: degree (input/output)

PROPAGATOR:

- Analytical propagator: two body/SGP/SGP4
- Can limit to two body
- Tabular/graphical close approach determination (user defined primary, minimum box size and minimum spherical separation distance; user defined time interval, computes table, displays encounter event)

BALLISTIC/LAUNCH TRAJECTORY:

- Calculates trajectory given latitude/longitude of launch and target
- Launch window analysis: determined opportunities to reach specified orbit from specified launch site

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/geodetic altitude
- Element set from propagator
- Visibility azimuth/azimuth-rate/elevation/elevation-rate/range between site/satellite

ANALYSES:

- Debris analysis

GROUND SITES:

- Defined by latitude/longitude/altitude

SENSOR OPTIONS:

- Define sensor cone with elevation/azimuth

GRAPHICS:

- Maps: zoomable/3D perspective (spherical Earth)
- Maps show coastlines/islands/countries/states/lakes/rivers
- Save to file/Print to color/laser printer
- Ground/orbit tracks for all satellites/missiles
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours
- Sensor view window
- Sensor 3D cone
- Display solar terminator conditions

FEATURES:

- On-line calculator
- Can filter space objects from catalog based on: satellite #, inclination, right ascension, eccentricity, argument of perigee, mean anomaly, mean motion, orbit period
- Missile manager: discrete missile launches for a variety of short, medium, and long range missile; volume missile launches, display detected/undetected launches, perform sensor detection analysis
- Sensor cones: wire frame, translucent solid, base ring on Earth surface, Earth coverage, user definable field of view angle Satellite nadir line

CONCERNS:

- Designed for limited distribution

LIFETIME v4.3

CONTACT:

The Aerospace Corporation
Dr. C. C. Chao
PO Box 92957
M4/948
Los Angeles CA 90009-2957
(310) 336-4295
FAX: (310) 336-5827
E-mail: chao@courier2.aero.org

- Lifetime simulation

PURCHASE INFORMATION:

- Cost: $50-$100
- All users must be supporting government contracts

SYSTEM REQUIREMENTS:

- PC
- Hard Drive Space: Executable - 300 KB

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Documentation available with technical/user information
- Software verified against TRACE and NORAD observed decayed objects by author
- Media Format: Disk

INPUT:

- GUI interactive menu

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines)

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: kilometers
- Angle: degree
- Time: Calendar date/Hours/Minutes/Seconds/ GMT
- Input and output units must be the same

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean NORAD 2-line element set (input)

PROPAGATOR:

- Numerical Gauss propagator with Runge-Kutta 7-8th order
- Semi-analytic mean propagator
- Coordinate system: Earth true equator mean equinox of 1JAN2000.00:00:00 (input/internal) of date (output)
- Maximum altitude = 5,000 km

PERTURBATIONS:

- Geopotential: WGS-84 (3x3)
- Atmospheric drag: MSIS 1990 E/Jacchia 1971
- Solar radiation pressure with cylindrical shadow modeling

- Lunar/solar body effects
- Spacecraft modeling: mass/drag coefficient/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns
- Calculates/simulates stationkeeping maneuvers (drag makeup)

OUTPUT CONTENT:

- Time history of apogee/perigee
- Lifetime analysis/re-entry predict

GRAPHICS:

- Maps: Mercator
- Instantaneous sensor footprint

FEATURES:

- Participated in Orbit Propagator Software Survey
- Predicts F10.7 and Ap to a fitted sine curve for 11 year cycle
- User defines solar array area that changes with time and satellite body area that is fixed over time
- Includes Differential Correction algorithm to estimate ballistic coefficient based on observed decay history (decreases predict error from 20 to 6%)(uses semi major axis and eccentricity as observables)

CONCERNS:

- Not a complete orbit analysis package

Linked Windows Interactive Data System (LinkWinds)

CONTACT:

Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109

PURCHASE INFORMATION:

- Cost: free
- All users must be supporting government contracts

SYSTEM REQUIREMENTS:

- Lynx

SOFTWARE STRUCTURE/SUPPORT:

- Written in LYNX (supports rerun script, journal and macro capability)

INPUT:

- GUI interactive menu

FEATURES:

- Visual data analysis environment - objects on screen are data, displays, and controls
- Objects are made interdependent by interactively linking them - links are message paths
- Functions like a graphical spreadsheet
- Multi-user science environment (MUSE) requires minimum network bandwidth and useful for cooperative scientific research, remote tutorials and user feedback

CONCERNS:

- Not a complete orbit analysis package
- Limited external distribution

LOKANGL

CONTACT:

Carl Hein
Radex, Incorporated
3 Preston Court
Bedford, MA 01730
(617) 275-6767
(617) 275-3303 fax
hein@ziggy.radex.plh.af.mil

- Satellite ephemeris prediction program using a Brouwer analytic expansion for J2 and J3 geopotential terms

SYSTEM REQUIREMENTS:

- MS-DOS®, UNIX, VAX-VMS
- Executable: 300KB

SOFTWARE STRUCTURE/SUPPORT:

- Documentation available -- user information
- Written in FORTRAN 77

INPUT:

- Namelist-like input
- Option menu for DOS version only

UNITS:

- Hours/Minutes/Seconds/Julian Date
- DU (distance unit - Earth Radii), kilometers
- Angle: radian/degree

ELEMENT TYPES:

- (Mean/Osculating) Earth Centered Inertial position and velocity (FK4/FK5) (input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Analytic propagator (perturbation expansion using Hill variables)

FEATURES:

- Provides viewing predictions for multiple sensors
- Mean element prediction and parameters of interest to geophysical applications
- Used for mission planning, post mission analysis, observation data processing

Long-Term Orbit Predictor (LOP)

CONTACT:

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
J. H. Kwok
Mail Station 301-170S
NASA Cosmic
Cosmic Order #NPO-17052
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Lifetime and planetary mission simulation

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $400 + $28 documentation

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision (compiled with Lahey 2.2)
- Documentation available

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (LOTUS 1-2-3 example usage)

CONVERSION/TRANSFER:

- General coordinate transformations (osculating to mean) (ASAP, sister program does return short periodics within an orbit revolution)

UNITS:

- Distance: kilometers
- Angle: degree
- Time: Second (time step may be in other units)
- Mass: Kg
- Input and output units must be the same

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input) (Mean - output)

PROPAGATOR:

- Numerical Variation of Parameters propagator with variable order integrator with variable step size
- Coordinate system: Earth true equator true equinox of epoch (input/output/internal)

PERTURBATIONS:

- Geopotential: (21x21)
- Atmospheric drag
- Solar radiation pressure
- Lunar/solar/n body effects
- No precession/yes nutation
- Central body replacement for extra-terrestrial orbits
- Spacecraft modeling: drag coefficient

OUTPUT CONTENT:

- Element set from propagator

FEATURES:

- Single average equations of motion for larger time step allowance - resonance trace terms are retained - some singularities when inclination is 0.0
- Samples for Geo drift, Venus mapping, Mars frozen orbit, repeat ground trace

CONCERNS:

- Not a complete orbit analysis package

LOTHRST

CONTACT:

The Aerospace Corp.
Julie A. Kangas
PO Box 92957
Los Angeles CA 90245-2957

- Finite burn simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- VAX with VMS/PC/Sun workstation

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PERTURBATIONS:

- Geopotential: J4
- Selenopotential (moon) models: J2
- Solar radiation pressure
- Lunar/solar/Earth body effects
- Central body replacement for extra-terrestrial orbits (moon/L4/L5 only)
- Engine thrusters

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns

PLANETARY:

- Predicts Earth/Lunar eclipses

FEATURES:

- Model solar cell degradation through van Allen belts

CONCERNS:

- Not a complete orbit analysis package
- Limited support group available
- Static program - being absorbed in to another PC SOAP

MacMASS

CONTACT:

ARGOSystems Inc.
324 North Mary Avenue
PO BOX 3452
Sunnyvale, CA 94088-3452
(408) 737-2000
Fax: (408) 524-3986
Dan Elliott (Technical)
(408) 524-1716

PURCHASE INFORMATION:
- Cost: free

SYSTEM REQUIREMENTS:
- PowerPC or 86k/SPARC/MIPS/SGI
- Operating system: MacOS/SunOS 4.1 or Solaris 2/IRIX 5
- RAM: 8 MB/16 MB/32 MB
- Hard Drive Space: Source Code - 3 MB; Executable - 2 MB; Data files - 30 MB
- Media Format: CD ROM

SOFTWARE STRUCTURE/SUPPORT:
- Written in C/ C++ with double precision
- Documentation available with user information
- Software verified against NORAD Spacetrack Report No. 3 by author
- Number of satellites limited only by memory

INPUT:
- GUI interactive menu

OUTPUT FORMAT:
- ASCII data - exportable to external plot routine

UNITS:
- Distance: feet/nautical miles (input/output)
- Angle: degree (input/output)
- Time: Calendar date/Minutes/Seconds
- Internal Units: Modified Julian Date/seconds/nautical miles/feet/radian

ELEMENT TYPES:
- Mean Classical Keplerian (input/output)
- Mean Earth Centered Inertial position and velocity (input/output)
- Mean Earth Centered Earth Fixed position and velocity (input/output)
- Mean NORAD 2-line element set (input/output)
- Naval Space Command (PME) 1-line element set (input/output)

PROPAGATOR:
- Analytical propagator: SGP4
- Coordinate system: Earth mean equator mean equinox of 1JAN1950.00:00:00 (input/output/internal)
- Maximum altitude = 36,000 km
- Minimum altitude = 0 km

OUTPUT CONTENT:
- Save to file
- Element set from propagator
- Visibility between site/satellite or satellite/target
- Output can be limited to time of constraint satisfaction

- Constraint satisfaction summary profile (average length/average gap/minimum length/maximum gap/maximum length/# occurrences/% time)

ANALYSES:

- Multi-site/vehicle/target simulation
- Ground coverage analysis
- Minimum power received & minimum G/T analysis

GROUND SITES:

- Defined by latitude/longitude/altitude

SENSOR OPTIONS:

- Define sensor cone with elevation/azimuth/range
- Additional sensor patterns (rectangle)

TARGETS/VEHICLES:

- Can create areas of interest used in visibility analysis/for plotting only
- Ships/ground vehicles/airplanes

GRAPHICS:

- Maps: Mercator/ 3D perspective (spherical Earth)/North Pole view
- Ground tracks for all satellites/targets
- Sensor ground swaths/instantaneous sensor footprint/Earth coverage contours/omni-antenna signal strengths from visible regions

FEATURES:

- Participated in Orbit Propagator Software Survey
- Macintosh version of MASS (Mission Analysis Support System) for GALVANIZE on VAX and HP3000

MacSat

CONTACT:

BEK Developers
Bill Bard
PO Box 47114
St. Petersburg FL 33743-7114

- General purpose mission analysis

PURCHASE INFORMATION:
- Cost: $10

SYSTEM REQUIREMENTS:
- Macintosh

SOFTWARE STRUCTURE/SUPPORT:
- Number of sites limited (100)/Number of satellites limited (200)

INPUT:
- GUI interactive menu/batch processing

OUTPUT FORMAT:
- ASCII/text data

PERTURBATIONS:
- Atmospheric drag

BALLISTIC/LAUNCH TRAJECTORY:
- Launch window analysis: (outputs orbit plane crossing times)

OUTPUT CONTENT:
- Save to file/Print to laser printer
- Time history of latitude/longitude/equator crossing times
- Visibility azimuth/elevation/geocentric right ascension and declination between site/satellite and satellite/satellite

ANALYSES:
- Multi-site/vehicle/target simulation
- Ground coverage analysis

GROUND SITES:
- Defined by latitude/longitude/altitude

GRAPHICS:
- Maps: Mercator
- Ground tracks for all satellites

FEATURES:
- Must choose block of satellites or sites

CONCERNS:
- Number of sites/satellites limited

MANS

CONTACT:

United States Air Force
PL/VTS
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-7990

- Determines spacecraft yaw required to acquire sun and moon in sensor if spacecraft is nadir pointing and solar tracking

PURCHASE INFORMATION:
- Cost: free

SYSTEM REQUIREMENTS:
- Any platform with FORTRAN compiler
- Hard Drive Space: Source Code - 120 KB; Executable - 168 KB (Macintosh); Data files - 15 KB
- Media Format: FTP/Disk

SOFTWARE STRUCTURE/SUPPORT:
- Written in FORTRAN 90 with double precision
- Open structure - modifications easy/designed to be portable
- Source code available
- Documentation available with technical/user information
- Software verified against TAOS satellite data by TAOS program office

INPUT:
- Namelist input
- Keyboard prompted

OUTPUT FORMAT:
- ASCII data - exportable to external plot routine

UNITS:
- Distance: kilometers
- Angle: degree
- Time: Calendar date/Hours/Minutes/Seconds/UT
- Internal Units: DU (distance unit - Earth Radii)/radian/Julian Date

ELEMENT TYPES:
- Mean/Osculating Classical Keplerian (input/output)

PROPAGATOR:
- Analytical propagator: two body/two body + J2
- Can limit to two body
- Can propagate forward/backward in time

PERTURBATIONS:
- Geopotential: none/J2

PLANETARY:
- Sun/Moon positions and velocities
- Planetary ephemerides in position and velocity
- Planetary ephemeris origin: Astronomical Almanac

OUTPUT CONTENT:
- Element set from propagator
- Visibility between satellite/sun and satellite/moon
- Object in sunlight

SENSOR OPTIONS:

- Additional sensor patterns: up to 2 dual cone scanning sensors (Microcosm Corporation)

FEATURES:

- Participated in Orbit Propagator Software Survey
- Can choose yaw and arc obstruction zones of scanning sensor
- Determines yaw for any combination of sun/moon out of sight
- Outputs yaw for sun only and moon only visibility if required

CONCERNS:

- Not a complete orbit analysis package
- Limited support group available
- Number of sites/vehicles/targets limited
- Static program - no plans to update
- Requires external program for plotting

MEANELT

CONTACT:

The Aerospace Corp.
2350 E El Segundo Blvd.
El Segundo, CA 90245
Ron Hopkins
(310) 336-7863

- Long term orbit propagation and orbit maintenance

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- SUN SPARC 10 workstation
- Operating system: UNIX
- RAM: 16 MB
- Hard Drive Space: Source Code - 2 MB; Executable - 1 MB; Data files - 8 MB
- Media Format: FTP

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Documentation available with technical/user information
- Software verified against TRACE by R. G. Hopkins (Aerospace Corporation)
- Number of satellites limited to one per simulation
- Software origin from: ELEMENT

INPUT:

- Namelist input

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Distance: nautical miles/kilometers
- Angle: degree
- Time: Day of Year
- Internal Units: nautical miles/kilometers/degree/radian/day of year

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (output)

PROPAGATOR:

- Semi-analytic mean propagator: Draper (mean + short periodics)
- Coordinate system: Earth mean equator mean equinox of 1JAN1950.00:00:00/true equator true equinox of epoch/true equator mean equinox of epoch (input/output)
- Maximum altitude = >36,000 km
- Minimum altitude = 1,000 km

PERTURBATIONS:

- Geopotential: GEM-1 (21x21)/GEM-10 (21x21)/WGS-72 (10x10)/WGS-84 (12x12)
- Atmospheric drag: Static Harris-Priester/Jacchia-Walker-Bruce
- Solar radiation pressure
- Interpolated lunar/solar body effects
- Spacecraft modeling: mass/drag coefficient/cross-sectional area
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns

- Calculates/simulates stationkeeping maneuvers

PLANETARY:

- Sun/Moon positions and velocities
- Planetary ephemeris origin: JPL

OUTPUT CONTENT:

- Element set from propagator

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

Methods and Realization for Control for the Attitude and the Orbit of Spacecraft (Mercator)

CONTACT:

Centre National D'Eturdes Spatiales (CNES)
Division Mathematiques Spatiales
18 avenue Edouard Belin
31055 Toulouse
France
Int. Code 33 - 61-27-44-25
FAX: Int. Code 33 - 61-27-49-60

- Real-time spacecraft bus operations

PURCHASE INFORMATION:

- Cost: unknown
- Future developments: Universal Mercator Operational Test in 1993

SYSTEM REQUIREMENTS:

- SUN
- Operating system: UNIX/SOLARIS/ X IIRES/MOTIF

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/C
- Object oriented design
- Open structure - modifications easy/designed to be portable/supports multiple networked users
- Interfaces with external programs: any program interface through UNIX socket/links with NOAA and France to get F10.7 and Ap updates
- Accuracy of 20 km in semi-major axis in orbit determination

INPUT:

- GUI interactive menu/batch processing
- Column formatted file

OUTPUT FORMAT:

- ASCII/text data

PROPAGATOR:

- Semi-analytic mean propagator

PERTURBATIONS:

- Geopotential: GEM-10 (6x6)
- Atmospheric drag: DTM/Jacchia
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Kalman filter
- Observation types: radar/SGLS/Ephemeris/satellite-satellite tracking (INTELSAT)
- Orbit determination automatically informed of planned maneuvers
- Real-time/batch orbit determination

ATTITUDE DETERMINATION:

- Weighted Least Squares/Kalman filter
- Real-time/batch modes

ORBIT MANEUVERS:

- Impulse burns
- Simulates stationkeeping maneuvers

PLANETARY:

- Predicts Earth/Lunar eclipses
- Star catalogue

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input observations
- Visibility between site/satellite

ANALYSES:

- Multi-site/satellite simulation

GROUND SITES:

- Defined by latitude/longitude

SENSOR OPTIONS:

- Additional sensor patterns: star tracker
- Ground coverage analysis

FEATURES:

- Man/CPU interface in French but not too hard to understand
- Consists of 4 SUN workstations totally redundant linked in an Ethernet network
- Takes only 3 people at workstations (fourth is for hot redundancy) to perform flight dynamics tasks related to a complete geostationary positioning
- Each workstation provides elementary functions of data pre-processing, system monitoring, time synchronization, and a shell environment for implantation, modification, and implementation of application software.
- Takes received telemetry from the satellite and localization measurements from ground station (CNES, NASA, INTELSAT...) and processed by space dynamics
- Can process Ariane telemetry already - just need to customize this for whatever telemetry format is used - can do real time (de-commutation)
- Analyses are distributed to other entities via a video network in static alphanumerical pages (i.e. maneuver pages with telecommand to spacecraft), dynamical alphanumerical pages (i.e. real time display of orbital elements or telemetry parameters), and graphical displays on telemetry parameters (i.e. results of telemetry processing)

Methods of Astrodynamics

CONTACT:

United States Air Force
PL/VTS
Maj. David Vallado
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-4056

- Library of reusable software components

PURCHASE INFORMATION:

- Cost: free
- Future developments: C version/upgrade due out in Summer, 1996 (with Vallado book)

SYSTEM REQUIREMENTS:

- Any platform with FORTRAN or Pascal compiler

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/PASCAL with double precision
- Documentation available with technical information

CONVERSION/TRANSFER:

- Between element sets: Cartesian position and velocity/Classical Keplerian and vice versa
- Between hour-min-sec/degree-min-second to radians and vice versa
- Converts between Calendar date with time/GMT/LST/GST/UT/Julian Date/Day of Year
- Converts between geodetic to geocentric latitude and vice versa
- General time and coordinate transformations

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order/Runge-Kutta-Fehlberg 4th order integrator
- Can limit to two body

PERTURBATIONS:

- Geopotential: none/J2
- Atmospheric drag: Static exponential/Chebyshev polynomial
- Lunar/solar body effects

ORBIT DETERMINATION:

- Gibbs: determines middle velocity vector from 3 position vectors
- Herrick-Gibbs: determines middle velocity from 3 position vectors and times

BALLISTIC/LAUNCH TRAJECTORY:

- Calculates trajectory given latitude/longitude of launch and target
- Calculates trajectory given latitude/longitude/range/azimuth of launch and determines target

ORBIT MANEUVERS:

- Calculates/simulates stationkeeping maneuvers (node and/or plane change)
- Calculates time of flight and velocity needed for Hohmann/one tangent/bi-elliptic burn transfer between two orbits
- Determines velocity needed to intercept target (Gauss Method - given R1, R2, Direction, Time of Flight)
- Determines velocity and wait time needed to rendezvous coplanar/non-coplanar target (Hill Method)

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Predicts Earth/Lunar eclipses
- Planetary ephemerides in position and velocity
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Interplanetary targeting (Hohmann transfer between two planets)

OUTPUT CONTENT:

- Visibility azimuth/elevation/range/range-rate/topocentric right ascension and declination/geocentric right ascension and declination between site/satellite and range/range-rate between satellite/satellite
- Sun rise/set times
- Re-entry predict (Allen-Eggars approximation - deceleration and velocity)

GROUND SITES:

- Defined by geodetic latitude/longitude/altitude

FEATURES:

- Find C&S coefficients
- Solves ballistic time of flight for rotating Earth and ICBM
- Position and velocity vectors from latitude/longitude/speed
- Calculates position vector for ground site
- Newton Rhapson iteration for eccentric anomaly
- Mathematical routines: cotangent of angle, cosecant of angle, secant of angle, inverse hyperbolic cosine, dot product of two vectors, cross product of two vectors, magnitude of vector, make unit vector, rotation about 1st axis, 2nd axis, or 3rd axis, addition of 2 vectors, addition of 3 vectors, combination of a scalar and vector, combination of 2 scalars and 2 vectors, combination of 3 scalars and 3 vectors, angle between two vectors, find roots of 16th order polynomial, solve roots of quadratic, solve roots of cubic, solve roots of quartic, scalar times a matrix, matrix multiply, matrix addition, matrix subtraction, matrix transpose, matrix inverse, print matrix, matrix determinant, sign of argument, equation for plane

CONCERNS:

- Not a complete orbit analysis package
- Some features not fully tested

MicroCosm Software System

CONTACT:

Van Martin Systems, Inc.
Thomas V. Martin
PO Box 2203
Rockville, MD 20847-2203
(301) 468-2095
FAX: (301) 770-6555

- High accuracy orbit determination

PURCHASE INFORMATION:

- Cost: $10,000 for each set of executables
- Purchase options: $20,000 for limited source code option (~99% of source code)

SYSTEM REQUIREMENTS:

- VAX with VMS/HP 9000 Series 800/PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

INPUT:

- Column formatted file

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Time: UTC (with leap seconds)/UT1/Global Positioning Time

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (FK5) (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (FK5) (input/output)

PROPAGATOR:

- Numerical Cowell propagator with multi-step predictor-corrector integrator up to 15th order
- Can propagate forward/backward in time through integration/interpolation
- Coordinate system: Earth true equator true equinox of 1JAN2000.00:00:00 (input/output/internal)

PERTURBATIONS:

- Geopotential
- Atmospheric drag
- Solar radiation pressure
- Lunar/solar/n body effects
- Earth tides, ocean tides, ocean loading/tectonic plate motion/precession/nutation/ pole wander
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Bayesian Least Squares
- Observation types: radar/SGLS/laser ranging/telescope (angles only)/Global Positioning system (GPS) (including single, double, and triple differences)/TDRSS range and range-rate/PRARE/Ephemeris/DORIS/ TRANET/GEORECEIVER Dopplers/direction cosines
- Measurements: (range/range-rate)/range difference/(azimuth/elevation)/(right ascension/declination)/radar altimeter
- Solve for parameters: pass dependent (range biases/refraction/clock errors)/data error correction /residuals

ORBIT MANEUVERS:

- Finite burns
- Input thrust vector in spacecraft/inertial coordinate frame

OUTPUT CONTENT:

- Element set by orbit determination from input/simulated observations

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Each data arc may have up to 99 observations
- Up to multiple data arcs supported
- Corrections for offsets of antennas and reflectors and range-rate data
- Annual, aberration, diurnal aberration and parallactic refraction effects
- Tropospheric refraction propagation delay and bending effects
- Corrections for range measurement for transponder delay and ranging ambiguities
- A general 3 axis model can be used to define a low thrust model in orbit plane coordinates or sun-oriented system

USERS:

- USAF CSTC

CONCERNS:

- Not a complete orbit analysis package
- Requires external program for covariance analysis of estimate partials (Aerodyne)

MicroGlobe

CONTACT:

Microcosm Inc.
2377 Crenshaw Blvd., Suite 300
Torrence, CA 90501
(310) 320-0555
FAX: (310) 320-0252
E-mail: softsmad@aol.com
http://www.sblink.com/microcosm

- Static/dynamic satellite skyfield as seen by a spacecraft

PURCHASE INFORMATION:

- Cost: $1,995

SYSTEM REQUIREMENTS:

- PC, MS-DOS®, 386 or better
- Math co-processor recommended

SOFTWARE STRUCTURE/SUPPORT:

- Documentation available with user information
- Support group available

INPUT:

- GUI interactive menu

RUN-TIME OPTIONS:

- Restart capability
- Quit/pause/return to original epoch
- Simulation runs in accelerated
- Simulation playback

OUTPUT FORMAT:

- Screen plot (2D lines/2D contours/3D contours) (over 30 2D/3D object types)

OUTPUT CONTENT:

- Save to file/Print to color/laser printer/rescalable chart recorder with up to 6 channels and 4 pens each

GRAPHICS:

- Maps: zoomable/celestial sphere (satellite at center)
- Save to file/Print to color/laser printer/rescalable chart recorder with up to 6 channels and 4 pens each
- Orbit tracks for all satellites
- Sensor view window (Earth disk/sun disk/celestial objects/other satellites/parts of same satellite)

FEATURES:

- Hierarchical reference frames simplify model building
- All associated angles computed and displayed
- Rapid global rotation at 50 frames/min using arrow keys

CONCERNS:

- Not a complete orbit analysis package

MinRng

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Gary Green
(310) 336-8761
Steve Sedlacek
(310) 336-1282

- Satellite close approach simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- CDC

OUTPUT CONTENT:

- Visibility range between satellite/satellite
- Constraint satisfaction summary profile (minimum range/maximum range)

ANALYSES:

- Probability of collision

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution
- Current status unknown

Missile Flight Tool (MFT)

CONTACT:

SAIC
Applied Technology Group
6725 Odyssey Drive
Huntsville, AL 35806
(205) 971-6563

- High fidelity ballistic missile flight trajectory generator derived from official DoD software

FEATURES:

- Simulates boost phase, post boost vehicle, payload and object deployment phase, and re-entry phase
- Single and multi-stage booster systems
- Single and multiple reentry vehicle payload deployment operations
- Integrated with STK via Inter-Processor Communications module (IPC)
- Generates STK vehicles
- Depicts missile flight in STK visualization option, including staging and deployment of reentry vehicles
- Models strategic, theater and test missiles, short to long range rockets
- Models several missile guidance modes
- Worldwide launch and target point selection

Monte Carlo Investigation of Trajectory Operations and Requirements (Monitor)

CONTACT:

NASA Goddard Spaceflight Center
Cosmic Order #GSC-12705
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Maneuver simulation

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $56 documentation

SYSTEM REQUIREMENTS:

- IBM 360 series

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN IV
- Documentation available

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D histogram)

PROPAGATOR:

- Analytical propagator: two body (state covariance matrix propagation)
- Can limit to two body

PERTURBATIONS:

- Engine thrusters

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns
- Pre-set burn/coast times

ANALYSES:

- Monte Carlo dispersion analysis/graphics show probability distributions (up to five variables)

FEATURES:

- GEO parking orbit injection through station acquisition
- Space shuttle deployed missions
- Single maneuver and comet encounter trajectories, mid-course maneuvers can be made to correct burn error and comet movements

CONCERNS:

- Not a complete orbit analysis package
- Spherically symmetric Earth

Multi-Sensor Analysis Tool (MSAT)

CONTACT:

Advanced Technology Center
Lockheed Missiles and Space Company
3215 Hanover St.
Palo Alto, CA 94304-1191
Dean Lundholm
O/H1-52, B/254G
(415) 425-3554
(415) 354-5002 fax

- Application independent shell - user inputs equations to analyze a particular model

PURCHASE INFORMATION:

- Cost: Unknown
- Future developments: default knowledge base

SYSTEM REQUIREMENTS:

- Operating system: UNIX/Macintosh (Macintosh version almost complete)

SOFTWARE STRUCTURE/SUPPORT:

- Written in C (each N variable equation generates N separate internal equations which in turn generates N internal C code solving routines)
- Open structure - modifications easy/designed to be portable
- Documentation available with technical/user information
- On-line help
- Interfaces with external programs: any

INPUT:

- GUI interactive menu
- Column formatted file (spreadsheet inputs)

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D/3D)

ANALYSES:

- Monte Carlo dispersion analysis/graphics show probability distributions

FEATURES:

- Aid for design and parametric analysis of any model defined by scalar equations (fluid dynamics, orbital mechanic, optical sensors, structures, thermodynamics)
- Every parameter can be an input or output - once model entered, you can vary any parameter and monitor/plot its effects on any other related parameter

CONCERNS:

- Not a complete orbit analysis package
- Not specifically developed for orbit analysis applications

NASA IDEAS

CONTACT:

NASA Center for Aerospace Information
Manager Technology Transfer Office
800 Elkridge Landing Rd
Linthicum Heights, MD 21090-9908

- 6-DOF spacecraft orbit simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- DEC workstation

SOFTWARE STRUCTURE/SUPPORT:

- Interfaces with external programs: SDRC I-DEAS (3D CAD/CAM)

PERTURBATIONS:

- Atmospheric drag

ATTITUDE DETERMINATION:

- Spin/3-axis stabilized modeled

OUTPUT CONTENT:

- Lifetime analysis/re-entry predict

ANALYSES:

- 6DOF (multi rigid body) vehicle dynamics simulation

GRAPHICS:

- Animated graphics in simulation
- 3D vehicle structure definition
- View vehicle attitude

FEATURES:

- Spacecraft cost module
- Thermal radiation codes

CONCERNS:

- Requires external program (SDRC I-DEAS) for graphics display

NewGap

CONTACT:

The Aerospace Corp.
Bill Adams
(310) 336-5279
PO Box 92957
Los Angeles CA 90245-2957

- Software analysis of war start-time on a space based kinetic energy weapon defense system (i.e. number of assignable satellites that can participate in an engagement as well as RV leakage)

PURCHASE INFORMATION:

- Cost: free

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation
- Launch window analysis: determined opportunities to reach specified orbit from specified launch site

OUTPUT CONTENT:

- Visibility between site/launch vehicle

ANALYSES:

- Optimization through iteration

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Variable time and section of trajectory

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

NORADC

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
George Chao
(310) 336-4295

- Close approach simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- CDC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

ELEMENT TYPES:

- Mean NORAD 2-line element set (input)

PROPAGATOR:

- Analytical propagator: SGP4

ANALYSES:

- Probability/lethality of collision

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution
- Outdated code

NOVAS

CONTACT:

US Naval Observatory
George Kaplan
Astronomical Applications Dept.
Washington DC 20392

- (Library of subroutines

PURCHASE INFORMATION:

- Cost: free
- Future developments: C version of library

SYSTEM REQUIREMENTS:

- Any platform with FORTRAN compiler

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN
- Source code available
- Documentation available with technical/user information
- Accuracy of 1 milliarcsecond

CONVERSION/TRANSFER:

- General coordinate transformations (precession/nutation/aberration/parallax/ gravitational deflection of light)

UNITS:

- Distance: AU (astronomical unit-Earth-Sun mean distance)
- Angle: arcsecond

ELEMENT TYPES:

- Solar System Barycentered Centered Inertial position and velocity (input)

PROPAGATOR:

- Coordinate system: Solar System Barycenter J2000.0 (input/output/internal)

PLANETARY:

- Sun/Moon/planetary/star positions (apparent/topocentric/astrometric)

FEATURES:

- Subroutines are vector based and consistent with IAU resolution
- Alternate versions are given for some basic and utility subroutines to offer different accuracies and run times
- Basic subroutines set values of fundamental constants
- Supervisory subroutines call basic and utility subroutines to form subroutine groups

CONCERNS:

- Not a complete orbit analysis package
- Requires external program for star catalog or planetary ephemeris

Numerical Prediction of Orbital Events (NPOE)

CONTACT:

Science Software
C. David Eagle
PO BOX 621022
Littleton, CO 80162-1022
(303) 904-2528
FAX: (303) 904-2528
e-mail: scisoft@concentric.net

- General purpose mission analysis

PURCHASE INFORMATION:

- Cost: $100

SYSTEM REQUIREMENTS:

- 80386/80486/Pentium
- Operating system: MS-DOS® 3.0 or higher
- RAM: 4 MB
- Hard Drive Space: Executable - 5 MB
- Media Format: 3 1/2" disks

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision (Shareware version in QBASIC)
- Documentation available with technical/user information
- Software verified against ASAP by author (Keplerian verification/calibration)

INPUT:

- GUI interactive menu
- Column formatted file

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines with autoscaling and 'smart' cursor)

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: kilometers
- Angle: degree
- Time: Calendar date/UT/Hours/Minutes/Seconds (input/output)
- Internal Units: kilometers/degree/Julian date

ELEMENT TYPES:

- Mean Classical Keplerian (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (output)
- Mean/Osculating Earth Centered Earth Fixed position and velocity (output)
- Mean NORAD 2-line element set (input)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta-Fehlberg 7-8th order
- Can limit to two body
- Coordinate system: Earth true equator true equinox of epoch (input/output/internal)
- Maximum altitude => 36,000 km
- Minimum altitude = 0 km

PERTURBATIONS:

- Geopotential: none/GEM-T3 (40x40)/JGM-2 (70x70)/JGM-3 (70x70)/WGS-84 (18x18)

- Atmospheric drag: Static Jacchia 1970/US Standard 1976
- Solar radiation pressure with conical shadow modeling
- Lunar/solar body effects
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area

PLANETARY:

- Sun/Moon positions and velocities
- Predicts Earth/Lunar eclipses
- Planetary ephemeris origin: USNO

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of geodetic latitude/longitude/equator crossing times (ascending and descending)/altitude/flight path angle/geocentric declination/orbital velocity
- Element set from propagator
- Visibility azimuth/elevation/range between site/satellite
- Predicts Earth/Lunar eclipses
- Sun rise/set times
- Object in sunlight/moonlight
- Satellite heading N/S

GROUND SITES:

- Defined by geodetic latitude/longitude/altitude

GRAPHICS:

- Maps
- Save to file/Print to color/laser printer

FEATURES:

- Participated in Orbit Propagator Software Survey

CONCERNS:

- Number of satellites limited to one
- Requires external program for input file editing (can be invoked from within NPOE)

Orbit Analysis and Simulation Software (OASIS)

CONTACT:

NASA and Caltech/JPL
Cosmic Order #NPO-17442
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- High accuracy propagation and orbit determination (especially GPS)

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $5,000 + $82 documentation

SYSTEM REQUIREMENTS:

- Dec VAX or MicroVAX

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Documentation available

CONVERSION/TRANSFER:

- General time and coordinate transformations

PERTURBATIONS:

- Atmospheric drag
- Solar radiation pressure
- Lunar/solar/n body effects
- Earth albedo
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas
- Vehicle attitude
- Engine thrusters (gas leaks)

ORBIT DETERMINATION:

- Automatic smoothing of incoming data
- Solve for parameters: residuals

OUTPUT CONTENT:

- Element set from propagator
- Element set by orbit determination from input/simulated observations

ANALYSES:

- Multi-site/satellite simulation

FEATURES:

- Path/Vary Module: generates satellite trajectories
- REGRES Module: should measurement be made (geometry, time inputs)
- PMOD Module: modifies REGRES for analyses
- FILTER/SMOOTHER Module: multi-satellite precise orbit determination
- OUTPUT PROCESSOR Module: translates F/S covariance into easy-to-read quantities

CONCERNS:

- Not a complete orbit analysis package

OASIS - CC

CONTACT:

CU-LASP (developer)
Aerospace Corporation
Ric Agardy
2350 E. El Segundo
MS M5/396
LA, CA 90009-2957
(310) 336-5878

- Space mission integration/test/operations tool

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Sun workstation

SOFTWARE STRUCTURE/SUPPORT:

- User creates procedures in CSTOL (command and control language)
- User develops GUI with TAE+ (from NASA)
- Open structure - modifications easy/designed to be portable

FEATURES:

- Monitors and controls spacecraft during integration, test, and on-orbit operations
- Developed for small to medium scientific satellite systems

USERS:

- NASA/ESA/ARGOS/etc.

CONCERNS:

- Not a complete orbit analysis package

OASIS - PS

CONTACT:

CU-LASP (developer)
Aerospace Corporation
Ric Agardy
2350 E. El Segundo
MS M5/396
LA, CA 90009-2957
(310) 336-5878

- Space operations scheduler

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Sun workstation

FEATURES:

- Plans and schedules spacecraft activities and communications support

USERS:

- NASA/ESA/ARGOS/etc.

CONCERNS:

- Not a complete orbit analysis package

OASIS Mission Scheduler

CONTACT:

CU-LASP (developer)
Aerospace Corporation
Ric Agardy
2350 E. El Segundo
MS M5/396
LA, CA 90009-2957
(310) 336-5878

- Space operations scheduler

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Sun workstation

SOFTWARE STRUCTURE/SUPPORT:

- Open structure - modifications easy/designed to be portable/supports multiple networked users

INPUT:

- Can load experiment plans from modem/Internet

FEATURES:

- Timeline/schedule of activities/events
- Generates integrated schedule for instrument operations, space vehicle operations, and site support
- De-conflicts schedules
- Reads standard orbit analyst ephemeris event files on the Command and Control System (CCS) from TSC-1 LAN via CCS External Interface Element
- Reads standard Station Acquisition Listings from CCS via the TSC-1 LAN/EIE
- Output formats consistent with the current forms in use at TSC-1 for Program Action Plans and Manning Schedule Changes
- Output formats to update RTS Visibility Records on the CCS Operations Planning Database
- Can predict and track spacecraft power resource utilization
- Rules Database can be changed for each mission setup

USERS:

- NASA/ESA/ARGOS/etc.

CONCERNS:

- Not a complete orbit analysis package
- Requires external (OASIS-PS) program for environment

OASIS Telemetry Data Display Analysis

CONTACT:

CU-LASP (developer)
Aerospace Corporation
Ric Agardy
2350 E. El Segundo
MS M5/396
LA, CA 90009-2957
(310) 336-5878

- Telemetry display/analysis

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Sun workstation

SOFTWARE STRUCTURE/SUPPORT:

- Open structure - modifications easy (list driven database)/designed to be portable/supports multiple networked users
- Interfaces with external programs: OASIS-CC Database Engine/NASA TAE+ Human Machine Interface for GUI

FEATURES:

- Displays spacecraft and science instrument health and status data and can use IDL software for display of science data
- Creates command procedures by filling entries in database table
- Modified to create telemetry acquisition interface via CCS/EIE
- NASA/ESA/ARGOS/etc.

USERS:

- NASA/ESA/ARGOS/etc.

CONCERNS:

- Not a complete orbit analysis package
- Requires external (OASIS-CC) program for environment

OMNI

CONTACT:

Autometric Inc.
Barry Belian
1330 Inverness Dr. Suite 350
Colorado Springs CO 80910
(719) 637-8332
FAX: (719) 637-8535
e-mail: belian@autometric.com
http://www.autometric.com

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $27,000
- Cost to non-government: $30,000
- Future developments: compatibility with DAB orbit
- Purchase options: discount for multiple user copies/Socket Interface Option ($10,000) allows users to exchange information with outside programs (can drive Omni graphics with own propagator and add own mission specific software)/Terrain Module ($10,000)

SYSTEM REQUIREMENTS:

- Silicon Graphics workstation/IBM RS6000
- Operating system: IRIX 5.3 or greater/Open GL and X-Windows
- RAM: 64 MB recommended (32K minimum)
- Media Format: 4mm/8mm data tapes

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/C/C++ with double precision
- X/MOTIF used for GUI
- Open structure - modifications easy/supports multiple networked users
- Documentation available with user information
- Software verified against Spacetrack Report #3 test cases by Autometric Inc.
- Support group available
- Training courses available
- Number of satellites limited to 9,999
- Interfaces with external programs: Wings Mission Rehearsal/any program through Socket Interface/COMET for ballistic missile input

INPUT:

- GUI interactive menu
- Constellation input (Walker/Delta Mean Anomaly/Delta Right Ascension) (automatically phases to avoid collisions at pole)

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines)

UNITS:

- Angle: degree
- Internal Units: days/kilometers/radians

ELEMENT TYPES:

- Mean Earth Centered Inertial position and velocity (output)
- Mean Earth Centered Earth Fixed position and velocity (output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Analytical propagator: SGP4/SDP4
- Maximum altitude = >36,000 km
- Minimum altitude = 0 km

PERTURBATIONS:

- Geopotential: J2 (WGS-72)
- Atmospheric drag
- Lunar/solar body effects
- Spacecraft modeling: drag coefficient (B*)

PLANETARY:

- Sun/Moon/planetary positions
- Predicts Earth/Lunar eclipses
- Star catalogue (only for graphics)(can choose star as vehicle for visibility studies - but user must supply ephemeris from almanac)

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate/Doppler shift between site/vehicle or vehicle/vehicle
- Visibility constraint satisfaction summary profile (metrics for area of interest coverage)
- Object in sunlight

ANALYSES:

- Multi-site/vehicle/target simulation
- Ground coverage analysis

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (text/symbol)
- Ground sensor defined by elevation (min/max)/azimuth (min/max)/user defined (azimuth/elevation) profile/automatic (azimuth/elevation) profile from terrain data

SENSOR OPTIONS:

- Define sensor cone with elevation/azimuth
- Set pointing constraints: point in direction/object through macros
- Additional sensor patterns

TARGETS:

- Can create areas of interest used in visibility analysis
- Ships/ground vehicles/airplanes

GRAPHICS:

- Maps: zoomable/Mercator/3D perspective (spherical Earth)
- Maps show coastlines/islands/countries/states/lakes/rivers
- Map shows Earth altitude through color (shaded relief)/3D perspective (purchase Terrain Module or download DTED data from Defense Mapping agency)/surface generation (from LANDSAT data)
- Save to file/Print to color/laser printer
- Ground/orbit tracks for each satellites/vehicle with unique text/symbol ID
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours with unique text/symbol ID
- Visibility with site/vehicle/target (2D/3D)
- Sensor 3D cone
- Any text can be added to graphics within program
- Animated graphics in simulation
- 3D vehicle structure definition - size, shape, orientation of components, heat generation, storage, and dissipation characteristics, surface characteristics, material composition, and solar panel rotation algorithms (can input from SDRC IDEAS through translator)
- View vehicle attitude

- Display solar terminator conditions
- Can display incoming satellite imagery data (through Socket Interface)

FEATURES:

- Participated in Orbit Propagator Software Survey
- There is an elset filter that allows the user to filter out satellites from catalogue
- Import/export capability is provided for exchange of database information between Omni and other programs
- Visible and Infra-Red Signature simulator - Time-coordinated intensity values measured while object within field of view
- Different options can display objects while detected, after detected, or until detected
- Can do C^2 with socket interface - have some compatible software already

USERS:

- USSPACECOM/AFSPC/Army Joint Program Office

CONCERNS:

- Number of satellites limited to 9,999
- Requires external program (COMET) for ballistic missile simulation

Optimal Maneuver Analysis of Trajectories (OMAT)

CONTACT:

McDonnell Douglas Aerospace - Houston Division
Tom A Mulder
MDC1-512FD
16055 Space Center Blvd.
Houston, TX 77062-6208
(713) 283-1937
Cosmic Order #MSC-21112
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Maneuver planning tool for low thrust to weight ratio trajectories

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $1,500 + $22 documentation

SYSTEM REQUIREMENTS:

DEC VAX

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Documentation available
- Interfaces with external programs: Rendezvous SORT (dispersion tool)

PROPAGATOR:

- Numerical Runge-Kutta-Nystrom integrator with gradient Newton-Raphson iterator
- Can limit to two body

PERTURBATIONS:

- Engine thrusters

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns
- Calculates/simulates stationkeeping maneuvers
- Overrides on computed maneuvers to satisfy special requirements
- Calculates time of flight and velocity needed for Hohmann/one tangent/bi-elliptic/multi-burn transfer between two orbits
- Determines velocity needed to intercept target with many target conditions (optimization)
- Determines velocity needed to rendezvous target
- Real-time calculation
- Can optimize for fuel efficiency

FEATURES:

- Planning and re-planning (real-time) the number, location, direction, and magnitude of maneuvers to minimize expended on-board fuel

CONCERNS:

- Not a complete orbit analysis package

Optimal Maneuver (OPTMAN)

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Maneuver planning tool

PURCHASE INFORMATION

- Cost: free

SYSTEM REQUIREMENTS:

- CDC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

ORBIT MANEUVERS:

- Impulse/Finite burns
- Can optimize for fuel efficiency

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

Optimal Low Thrust Orbit Transfer (OPTRAN)

CONTACT:

NASA Lewis Research Center
Cosmic Order #LEW-14089
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Orbit transfer tool

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $19 documentation

SYSTEM REQUIREMENTS:

- DEC VAX

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Documentation available
- Number of satellites limited to two per simulation

PROPAGATOR:

- Analytical propagator: two body
- Can limit to two body

PERTURBATIONS:

- Engine thrusters

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns
- Calculates time of flight and velocity needed for Hohmann transfer between two orbits
- Can optimize for fuel efficiency (control through thrust direction or on/off times)
- Tracks fuel expenditure

FEATURES:

- Orbit transfer between non-coplanar circular orbits with chemical propulsion
- Can model long term burn arc and divided burn transfers
- Simulates either constant thrust or acceleration
- Can achieve exact solution or approximate solution (estimate for initial condition for exact solution)

CONCERNS:

- Not a complete orbit analysis package

Orbital and Geodetic Parameter Estimation Analysis (ORAN)

CONTACT:

NASA Goddard Spaceflight Center
Cosmic Order #GSC-12766
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Orbit determination error analysis

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $42 documentation

SYSTEM REQUIREMENTS:

- IBM 360 series

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN IV/ASSEMBLER
- Documentation available with technical/user information

PERTURBATIONS:

- Geopotential
- Atmospheric drag
- Solar radiation pressure
- Lunar/solar/n body effects
- Earth albedo/Earth tides
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Weighted Least Squares
- Measurements: (range/range-rate)/(azimuth/elevation)/(right ascension/ declination)/altimeter height/direction cosines/X&Y angles/satellite-satellite range/satellite-satellite range-rate
- Solve for parameters: station coordinates and velocities/Earth rotation/pass dependent (range biases/refraction/clock errors)/data error correction /residuals/radio source positions/polar motion/solid Earth tidal parameters/ocean tidal amplitudes and phases/tropospheric zenith delay/space plasmas

FEATURES:

- Not process data but accuracy of results of data reduction (measurements of given accuracy processed by minimum variance data reduction program is input)
- Simulates OD processing and computes error statistics of unadjusted (unestimated) parameters during OD
- Considers 1 satellite batch or satellite-satellite tracking analysis

CONCERNS:

- Not a complete orbit analysis package
- Number of satellites limited to one for analysis (2 if satellite-satellite tracking data)

Orbit - KKI

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
Paul Kisak
(703) 247-4333
FAX: (703) 869-0554

- General purpose mission analysis

PURCHASE INFORMATION:

- Cost: $375

SYSTEM REQUIREMENTS:

- Macintosh

SOFTWARE STRUCTURE/SUPPORT:

- Number of sites/vehicles/targets limited only by memory

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (Excel and graphics compatible with Microsoft® Word and Claris McDraw)

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Modified Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)

PROPAGATOR:

- Can limit to two body

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/altitude/apogee/perigee
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate site/satellite, site/target, satellite/satellite, and satellite/target
- Atmospheric compensation

ANALYSES:

- Ground coverage analysis (through Microsoft® Excel)

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (symbol)
- Ground sensor defined by elevation

GRAPHICS:

- Maps: zoomable/Mercator
- Save to file/Print to color/laser printer
- Ground tracks for all satellites/missiles with general symbol ID
- Sensor ground swaths

FEATURES:

- On-line astrodynamic calculator (compute period/semi-major axis/days between dates)

CONCERNS:

- Requires external program for plotting and analyze data for many studies (Microsoft® Excel)

ORBIT/A422GROUND

CONTACT:

United States Air Force
PL/VTS
Maj. David Vallado
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-4056

- General purpose mission analysis

PURCHASE INFORMATION:
- Cost: free

SYSTEM REQUIREMENTS:
- PC

SOFTWARE STRUCTURE/SUPPORT:
- Written in FORTRAN 77/PASCAL with double precision
- Source code available
- Number of sites limited to one/number of satellites limited to one

INPUT:
- GUI like input - smart editor with displayed options

RUN-TIME OPTIONS:
- Increase/decrease/return to original simulation step size

OUTPUT FORMAT:
- Screen plot (2D lines)

UNITS:
- Time: TU (time unit) (output)/Calendar date (input)/Hours (input)/Minutes (input)/Seconds (input)/LST (output)/GST (output)/Julian Date (input)/revolutions (set run time)

ELEMENT TYPES:
- Osculating Classical Keplerian (input)
- Osculating Earth Centered Inertial position and velocity (output)

PROPAGATOR:
- Analytical propagator: two body/two body + J2 + atmospheric drag
- Can limit to two body
- Can propagate forward/backward in time through integration/interpolation

PERTURBATIONS:
- Geopotential: none/J2
- Atmospheric drag: Static exponential

OUTPUT CONTENT:
- Element set from propagator
- Visibility between site/satellite

ANALYSES:
- Comparison between orbit propagators (2 body/2 body + J2) in ECI position and velocity/Classical Keplerian

GROUND SITES:
- Defined by geodetic latitude/longitude/altitude/ID (symbol)
- Ground sensor defined by elevation

GRAPHICS:
- Maps:Mercator
- Ground tracks for one satellite

FEATURES:

- Before plotting, shows user # of calculations for set time step, run time, & propagator

CONCERNS:

- Not a complete orbit analysis package
- Some features not fully tested
- No user documentation
- Limited support group available
- Number of sites limited to one/number of satellites limited to one

Orbit II

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
Paul Kisak
(703) 247-4333
FAX: (703) 869-0554

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $1,900

SYSTEM REQUIREMENTS:

- Sun workstation/Macintosh

SOFTWARE STRUCTURE/SUPPORT:

- Number of sites/satellites/targets limited only by memory

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (Excel and graphics compatible with Microsoft® Word and Claris McDraw)
- Screen plot (2D lines)

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Modified Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)

PROPAGATOR:

- Can limit to two body

PERTURBATIONS:

- Geopotential: (12x12)
- Central body replacement for extra-terrestrial orbits

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/altitude/apogee/perigee
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate site/satellite, site/target, satellite/satellite, and satellite/target
- Atmospheric compensation

ANALYSES:

- Ground coverage analysis (through Microsoft® Excel)

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (symbol)
- Ground sensor defined by elevation

GRAPHICS:

- Maps: zoomable/Mercator/3D perspective (spherical Earth)
- Save to file/Print to color/laser printer
- Ground tracks for all satellites with general symbol ID
- Sensor ground swaths
- Sensor view window
- Animated graphics in simulation

FEATURES:

- On-line astrodynamic calculator (compute period/semi-major axis/days between dates/Julian Date conversion)
- Instant access to all internal variables, data and relative plotting

CONCERNS:

- Requires external program for plotting and analyze data for many studies (Microsoft® Excel)

Orbit II Plus

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
Paul Kisak
(703) 247-4333
FAX: (703) 869-0554

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $5,900
- Purchase options: volume discounts: 2-5 copies: $3,170/12-20 copies: $1,450/30-50 copies: 953/65-100 copies: $575/more than 120 copies: $452

SYSTEM REQUIREMENTS:

- Sun Workstation/Macintosh

SOFTWARE STRUCTURE/SUPPORT:

- Source code available
- Number of sites/satellites/targets limited only by memory

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database
- Database of sites/satellites (domestic and international) available with software

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (Excel and graphics compatible with Microsoft® Word and Claris McDraw)
- Screen plot (2D lines)

CONVERSION/TRANSFER:

- Between element sets: Cartesian position and velocity/Classical and vice versa

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Modified Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)

PROPAGATOR:

- Can limit to two body

PERTURBATIONS:

- Geopotential: none/(12x12)
- Atmospheric drag: Static Harris-Priester (from JPL)

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue (includes stellar objects - galaxies, meteor showers, nebulae, etc.)
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Save to file/Print to color/laser printer

- Time history of latitude/longitude/equator crossing times/longitude of ascending node/altitude/apogee/perigee
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate site/satellite, site/target, satellite/satellite, and satellite/target
- Lifetime analysis/re-entry predict (analytic)
- Atmospheric compensation/rain attenuation

ANALYSES:

- Ground coverage analysis (through Microsoft® Excel)

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (symbol)
- Ground sensor defined by elevation

SENSOR OPTIONS:

- Define sensor cone with elevation/azimuth

GRAPHICS:

- Maps: zoomable/Mercator/3D perspective (spherical Earth)
- Save to file/Print to color/laser printer
- Ground tracks for all satellites with general symbol ID
- Sensor ground swaths/instantaneous and cumulative sensor footprint
- Ground station coverage contours with general symbol ID
- Sensor view window - does not display in terms of sensor field - displays +/- velocity vector of satellite or ground station overhead view
- Animated graphics in simulation
- Display solar terminator conditions

FEATURES:

- On-line astrodynamic calculator (compute period/semi-major axis/days between dates/Julian Date conversion/element transformation)
- Instant access to all internal variables, data and relative plotting
- Star field - allows you to point and click on star field to identify stars in sensor's FOV
- Can display visual magnitude of planets
- Has Excel models to simulate payloads - atmospheric compensation, vidicon/camera, infra-red passive/active, SAR, radar, boresight pointing, sun/ moon terminators, various antenna patterns (push broom, spotlight beams, wide area coverage beams, swaths), S/N studies G/T studies, path loss, received power, power budget studies, doppler, reflected power studies, receiver/transmitter capacity, maximum unambiguous doppler, time on target, multiple visibilities, mutual visibilities, tertiary visibilities, path loss, period and revisit calculations, stationkeeping requirements

CONCERNS:

- Requires external program for plotting and analyze data for many studies (Microsoft® Excel)

Orbital Lifetime Program

CONTACT:

NASA Langely Research Center
Cosmic Order #LAR-13557
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Lifetime simulation

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $20 documentation

SYSTEM REQUIREMENTS:

- DEC VAX
- Operating system: VMS

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Documentation available

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PROPAGATOR:

- Maximum altitude =2,500 km
- Minimum altitude = 64 km

PERTURBATIONS:

- Geopotential: J2
- Atmospheric drag: Static Jacchia (above 90 km)/US Standard 1976 (below 90 km)
- Solar radiation pressure
- Lunar/solar body effects

OUTPUT CONTENT:

- Lifetime analysis/re-entry predict

CONCERNS:

- Not a complete orbit analysis package

Orbital Workbench

CONTACT:

Cygnus Engineering
PO BOX 1805
Cupertino, CA 95015-1805
(408) 773-8366
Dan Kane

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $3,950 + $595 maintenance
- Future developments: port to Macintosh/Microsoft® Windows™/UNIX workstations
- Purchase options: Can purchase individual modules to limit price

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Number of satellites limited to 14 per simulation

INPUT:

- GUI interactive menu
- Can load sites/satellites/launch vehicles from database

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines/3D contour for true anomaly combination for optimal burns and relative motion)

CONVERSION/TRANSFER:

- Between any element sets
- General coordinate transformations (mean to osculating and vice versa)

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating spherical (input/output)
- Osculating equinoctial (input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order integrator (Universal Variable or Modified Keplerian formulation)
- Analytical propagator: SGP/SGP4/SDP4/SGP8/SDP8
- Can limit to two body

PERTURBATIONS:

- Geopotential: none (numerical)/(6x6) (numerical)/(12x12) (numerical)/J2-J3-J4 (analytical)
- Selenopotential (moon) models
- Atmospheric drag: Static Jacchia 1971 (numerical)/exponential (analytical)
- Solar radiation pressure (numerical)
- Lunar/solar body effects (numerical and analytical)
- Mars Geopotential and Atmospheric models: (18x18) and COSPAR drag model
- Central body replacement for extra-terrestrial orbits (full Mars and Lunar geopotentials with J2 given for all other planets in solar system)

ORBIT DETERMINATION:

- Estimation: Least Squares

- Measurements: (azimuth/azimuth-rate/elevation/elevation-rate/range/range-rate)/(right ascension/declination)/two position vectors and time between
- Orbit determination uses F&G expansion or true anomaly iteration depending on the size of angle between the two position vectors
- Propagator in orbit determination includes only J2

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation
- Customize up to 10 stages
- 3D thrust control (maximum G limit throttling or table entry of thrust to fix Isp or mass flow rate)/mass flow rate (initial and final)/time of ignition & release/aerodynamic coefficients by Mach number (use table entry)/angle of attack (time history via file/fixed/exponential rate/gravity turn/constant rate)/payload mass/dry mass/propellant mass/Isp (sea level and vacuum)/coast time/presented area
- Launch from space/air-borne platforms (initial relative velocity with respect to Earth)
- Initial vertical ascent with turn towards specified azimuth
- Interstage coasting
- Instantaneous mass losses during burn/coast
- Impact latitude/longitude calculated (ballistic and powered for re-entry analysis - can stage drag parameters to define parachute opening, etc.)

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns (finite burns through ballistic stages - but ballistic propagator only includes J2 and drag)
- Calculates/simulates stationkeeping maneuvers
- Calculates time of flight and velocity needed for Hohmann/one tangent/bi-elliptic/bi-parabolic burn transfer between two orbits
- Determines velocity needed to rendezvous target given time of flight
- Pre-set burn/coast times (up to 10 burns pre-set)
- Can optimize for fuel efficiency (using McCue/Lee optimal 2-impulse algorithm since only 5% if more burns)

PLANETARY:

- Sun/Moon/planetary positions and velocities (for time within 300 years of 1900)
- Sun position in spacecraft frame
- Predicts Earth/Lunar eclipses
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Ascent/descent time history of altitude/pitch angle/velocity/slant range/dynamic pressure/acceleration/downrange/flight path angle/mass/ thrust to weight ratio/angle of attack/thrust
- Time history of geocentric latitude/geodetic latitude/longitude/equator crossing times/longitude of ascending node/acceleration/mass/maneuvers/altitude/ velocity/orbit beta angle/revolution number
- Element set from propagator (orbit/ballistic)
- Visibility azimuth/elevation between satellite/sun
- Visibility azimuth/elevation/range/range-rate between site/vehicle (in site coordinate frame or satellite coordinate frame of reference)
- Sun rise/set times
- Re-entry predict (ballistic and powered for re-entry analysis - can stage drag parameters to define parachute opening, etc.)
- Object in sunlight
- Satellite heading N/S

ANALYSES:

- Proximity (< 100 km) operations between two vehicles - using Euler/Hill (Clohessy-Wiltshire)
- For relative motion: can plot in 2D or 3D satellite to satellite azimuth and elevation, range, curvilinear distances, radial, intrack, and crosstrack positions

GROUND SITES:

- Defined by geodetic or geocentric latitude/longitude/altitude
- Ground sensor defined by elevation/azimuth

SENSOR OPTIONS:

- Define sensor cone with elevation/azimuth
- Set pointing constraints: nadir pointing/fixed with respect to vehicle/fixed with respect to inertial frame/solar pointing (more accurate over a few days time)

GRAPHICS:

- Maps:Mercator/3D perspective (spherical Earth)
- Ground tracks for each satellite/missile with general symbol ID
- Sensor ground swaths

FEATURES:

- Major revision in progress
- On-line astrodynamic calculator for any planet (period/mean motion/semi-major axis/eccentricity/semi-latus rectum/apoapsis radius/altitude/velocity/escape velocity/periapsis velocity/position radius/circular velocity/true anomaly/mean anomaly/eccentric anomaly/time of flight/right ascension/declination/ inclination/argument of periapsis/right ascension of ascending node/apsidal rotation rate/nodal regression rate/rocket equations with ignition mass, burnout mass, propellant mass, inert mass, structural fraction, payload fraction, mass flow rate, burn time, specific impulse, thrust, and change in velocity (up to 4 stages computed) with bar graph displaying magnitudes of mass parameters
- Transfers data between different modules - so launch can flow into orbit without entering extra data
- Nominal guidance controls for all nine booster models - includes Ariane 4/Atlas II/Delta II/Delta H-II/Pegasus/Proton D-1/Space Shuttle/Titan IV with Centaur G upper stage/Titan IV without upper stage
- Impulsive burn model can be specified in ECI or intrack/crosstrack/radial coordinates

CONCERNS:

- Number of satellites limited to 14
- Precise propagator is not available in all modules (ballistic or orbit determination)

Orbit Analysis System (OASYS)

CONTACT:

Integral Systems Inc.
5000-A Philadelphia Way
Lanham, MD 20706-4417
(301) 731-4233
FAX: (301) 731-9606
e-mail: oasys@integ.com
http://www.integ.com/

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $35,000
- Purchase options: source code/multi-user network licenses

SYSTEM REQUIREMENTS:

- HP-PA/all SPARC/DEC Alpha/486 PC/Pentium PC/Pentium-Pro PC/Silicon Graphics
- Operating system: UNIX/OSF-1
- RAM: 32 MB
- Hard Drive Space: Executable - 15 MB
- Media Format: DAT/Disk/FTP-Internet

SOFTWARE STRUCTURE/SUPPORT:

- Written in C/C++ with double precision
- X-Windows/UNIX command shell/custom C used for GUI
- Open structure - modifications easy/designed to be portable/supports multiple networked users
- Source code available (under special arrangement)/Object code in OASYS Orbit Toolkit - orbit functions and C object module to create other applications compatible with OASYS
- Documentation available
- Tutorial
- Number of satellites limited to one for orbit determination only
- Software verified against NASA GTDS/DOD software/Aerospace Corporation TRACE/Lockheed-Martin MAS/Lockheed-Martin SOCS/Intelsat XDOMP/Hughes ORBOPS/operational data

INPUT:

- GUI interactive menu

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines - x-y and polar with zoom/splines/symbols)

CONVERSION/TRANSFER:

- Between element sets: any available/NORAD 2-line and any available/Intelsat 11 (minimizes residuals between OASYS ephemeris and output element set)

UNITS:

- Distance: kilometers
- Angle: radian/degree
- Time: UTC
- Internal Units: kilometers/radians/ephemeris time in SI seconds

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating equinoctial (input/output)
- Mean/Osculating F&G (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (FK5) (input/output)

- Mean/Osculating Earth Centered Earth Fixed position and velocity (FK5) (input/output)
- Mean/Osculating geodetic (input/output)
- Mean NORAD 2-line element set (input/output)
- Mean Brouwer (input/output)
- Mean Intelsat I-11 (output)

PROPAGATOR:

- Numerical propagator with Runge-Kutta 4th order integrator with variable step size/variable order Burlisch-Stoer rational function extrapolation with variable step size
- Analytical propagator: two body/SGP/Brouwer mean element
- Can limit to two body (analytic or numerical with all perturbations turned off)
- Can propagate forward/backward in time through integration
- Coordinate system: Earth mean equator mean equinox of any epoch/mean equator true equinox of any epoch/true equator mean equinox of any epoch/true equator true equinox of any epoch (input/output) true equator true equinox of date (internal)
- Maximum altitude = > 36,000 km
- Minimum altitude = 0 km
- Can simulate rectilinear/parabolic/hyperbolic orbits (in numerical propagators only)

PERTURBATIONS:

- Geopotential: none/GEM-10B (50x50)/GEM-T3 (50x50)/WGS-84 (50x50)/user supplied (50x50) (convenience buttons for none/J2/full geopotential and slider bars for setting degree and order)
- Atmospheric drag: Time varying Harris-Priester
- Solar radiation pressure
- Analytically propagated lunar/solar body effects
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas/multi-surface area elements/sensor complement/thruster complement
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Weighted Batch Least Squares with single value decomposition/a priori/a posteriori statistics for elements/residuals/biases (UNIX version)/Extended Kalman Filter with white process noise Qing (PC version)
- Manual/automatic smoothing/culling of incoming data (N-sigma threshold/point-click)
- Observation types: radar/laser ranging/Global Positioning System (GPS)/Ephemeris
- Measurements: (range/range-rate)/(azimuth/elevation)/satellite-satellite range/satellite-satellite range-rate
- Solve for parameters: solar radiation pressure/atmospheric drag/pass dependent (range biases/refraction/clock errors)/data error correction/residuals/satellite dynamic scaling parameters
- Batch orbit determination
- Allows a priori data for all estimates and uncertainties of all parameters

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns (continuous/on-pulsed/double on-pulsed/off-pulsed)
- Input thrust vector in spacecraft coordinate frame
- Calculates/simulates stationkeeping maneuvers
- Stationkeeping constraints: repeat ground track/sun synchronous/inclination/longitude of ascending node/1-2 part semi-major axis/1-2 part eccentricity/perigee constraints/geosynchronous North-South/East-West
- Overrides on computed maneuvers to satisfy special requirements
- Pre-set burn/coast times
- Tracks fuel expenditure

- Estimate thruster performance/trend information (modeled as function of thrust magnitude/direction/flow rate or table input of specific thruster model with orientation/mounting position given for each configuration)

PLANETARY:

- Sun/Moon positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/maneuvers/altitude/apogee/perigee/longitude excursions
- Element set from propagator
- Element set by orbit determination from input observations
- Visibility azimuth/elevation/between site/satellite

ANALYSES:

- Multi-site/satellite simulation

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation (min/max)/azimuth

GRAPHICS:

- Maps: zoomable/Mercator
- Save to file/Print to color/laser printer
- Ground tracks for each satellite
- Ground station coverage contours

FEATURES:

- Participated in Orbit Propagator Software Survey
- Graphic timeline/schedule of activities/events
- Convenience buttons for standard coordinate system selection (J1900/J1950/ J1958/J2000/MEME of date or any epoch/TEME of date or any epoch/TETE of date or any epoch)
- UNIX version allows multitasking through different windows
- OASYS assumes a tracking data preprocessor corrects for time tag of measurement
- Orbit determination reports: convergence/iterations/parameter correlation
- Orbit Maneuver tool plots: point and click on plot and changes maneuver; helpful for inclination and right ascension of the node maneuver
- Thruster models of bi-propellant and monopropellant included
- Can manipulate maneuver module for launch and re-entry trajectory analysis
- EPOCH 2000 telemetry processing and vehicle commanding system collects data from several computers where run in parallel: updates and check staleness of measurements with anomaly resolution via hierarchical system block diagrams (not automatic)
- Antenna prepositioning and real time control

Orbit Analyst Workstation (OAWS)

CONTACT:

Logicon Ultrasystems, Inc.
1350 Villa St.
Mountain View, CA 94041
Mr. Nicholas Chiochios, ext. 361
(415) 965-7190
FAX: (415) 964-4618
E-mail: nchiochios@logicon.com

- Space mission operations tool

PURCHASE INFORMATION:

- Cost: To be determined
- Cost to non-government: To be determined
- Future developments: generation of remainder of orbit and station events/attitude data processing and editing/orbit-related mission planning/attitude planning/multiple vehicle planning functions/integration with other COTS/GOTS packages is being considered

SYSTEM REQUIREMENTS:

- RISC 6000
- Operating system: AIX
- RAM: 64 MB
- Hard Drive Space: Source Code - 400 MB; Executable + Data files - 400 MB
- Media Format: data tapes

SOFTWARE STRUCTURE/SUPPORT:

- Written in Ada with double precision
- C/C++ used for GUI - SQL for database interactions
- Open structure - modifications easy/designed to be portable/supports multiple networked users
- Documentation available with technical/user information
- Software verified against the operational Air Force Satellite Control Network orbit subsystem (including trajectory integrator) in accordance with Formal Qualification Testing Standards (2167A)

INPUT:

- GUI interactive menu

OUTPUT FORMAT:

- ASCII/text data

UNITS:

- Distance: DU (distance unit - Earth Radii)
- Angle: radian/degree
- Time: UTC
- Internal Units: DU (distance unit - Earth Radii)/radian/minutes

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Earth Centered Inertial position and velocity (FK5) (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)
- Osculating equinoctial (input/output)

PROPAGATOR:

- Numerical Variation of Parameters finite difference propagator with Runge-Kutta 4th order/Bulirsch-Stoer integrator
- Can limit to two body

- Coordinate system: Earth true equator true equinox of date (input/output)/mean equator mean equinox 1 JAN 2000.00:00:00 (input/output/internal)
- Maximum altitude = > 36,000 kilometers
- Minimum altitude = 140 kilometers

PERTURBATIONS:

- Geopotential: none/WGS-84 (41x41)/user supplied
- Atmospheric drag: Static Jacchia (1960)
- Solar radiation pressure with conical shadow modeling
- Analytically propagated (9th degree polynomials) lunar/solar body effects
- Spacecraft modeling: drag coefficient/coefficient of reflectivity
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Least Squares
- Batch orbit determination

ATTITUDE DETERMINATION:

- Least Squares
- Batch modes

ORBIT MANEUVERS:

- Impulse/Finite burns

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/apogee/perigee
- Element set from propagator
- Element set by orbit determination from input/simulated observations
- Visibility azimuth (minimum/maximum)/elevation (maximum)/between site/satellite

GROUND SITES:

- Defined by latitude/longitude/altitude

FEATURES:

- Participated in Orbit Propagator Software Survey
- Supports C2 security level
- Can customize report generation (post-process)
- All ephemeris/attitude files available directly through Sybase
- Attitude and tracking observations can be viewed and edited graphically with multiple viewing options
- Orbit Analysis Toolbox includes: CIRA 1972/Jacchia-Roberts/planetary/Earth tides perturbations
- Orbit and attitude update: supports launch and early orbit as well as final on-orbit phases (for geosynchronous satellites only)
- Tracking data processing and editing: (automatic and graphical editing) - supports all orbit types

USERS:

- Air Force Satellite Control Network (first upgrade to AFSCN command and control segment - ISSS is second part)

OrbiTrak

CONTACT:

BEK Developers
Bill Bard
PO Box 47114
St. Petersburg FL 33743-7114

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $20

SYSTEM REQUIREMENTS:

- Macintosh

SOFTWARE STRUCTURE/SUPPORT:

- Number of satellites limited only by memory (in real-time simulation)/limited to one in accelerated mode

INPUT:

- Can load sites/satellites/stars from database
- Database of sites/satellites available with software

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine (Microsoft® Excel/Word/Claris MacWrite)

UNITS:

- Distance: nautical miles/statute miles/kilometers

ELEMENT TYPES:

- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Analytical propagator: SGP/SGP4/SDP4/SGP8/SDP8
- Can propagate forward/backward in time

BALLISTIC/LAUNCH TRAJECTORY:

- Launch window analysis: determined opportunities to reach specified orbit from specified launch site (orbit plane crossing times)
- Launch constraints: lighting conditions (noon/midnight)

PLANETARY:

- Sun/Moon positions
- Predicts Earth/Lunar eclipses
- Star catalogue (1,500)

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history options: time from epoch/date and time
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/altitude/apogee/perigee/orbital period/revolution number/velocity
- Element set from propagator
- Visibility azimuth/elevation/range/range-rate/topocentric right ascension and declination/frequency/doppler/separation angle/plane angle between site/satellite and satellite/satellite
- Visibility azimuth/elevation between site/sun and satellite/sun
- Sun rise/set times
- Can set Mission Elapsed Time clock

ANALYSES:

- Multi-site/satellite simulation

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation (minimum)/range (maximum)/frequency for doppler/minimum mean motion of satellite detected/sun angle (site can be dark or lit)

GRAPHICS:

- Maps: zoomable/Mercator/point interrogation
- Maps show coastlines/islands/countries/states/lakes/rivers
- Ground tracks for each satellite with general symbol ID
- Visibility with site/vehicle/target (2D - color change)
- Sensor view window

FEATURES:

- Filter to include/exclude for element (name, inclination, mean motion, epoch, eccentricity, international # designator) or site (lat., lon.) load or display
- Autosave with data and time of run
- Can output pass data in Voyager format to plot against a star background
- Can control KR-10 rotor through rotor control module and modem

CONCERNS:

- Number of satellites limited in accelerated mode

Orbitview

CONTACT:

Cygnus Engineering
918 Leighton Way
Sunnyvale CA 94087
(408) 773-8366
Dan Kane

- Orbit display simulation

PURCHASE INFORMATION:
- Cost: $950 + $195/year maintenance
- Future developments: Port to Macintosh/Microsoft® Windows™/UNIX workstations

SYSTEM REQUIREMENTS:
- Microsoft® DOS PC

SOFTWARE STRUCTURE/SUPPORT:
- Number of satellites limited to ten per simulation

INPUT:
- GUI interactive menu

RUN-TIME OPTIONS:
- Quit/pause/return to original epoch
- Increase/decrease simulation step size
- Simulation runs in accelerated time

PROPAGATOR:
- Analytical propagator: two body + J2

PERTURBATIONS:
- Geopotential: J2

PLANETARY:
- Sun/Moon/planetary positions

ANALYSES:
- Multi-satellite simulation

GROUND SITES:
- Defined by latitude/longitude

GRAPHICS:
- Maps: zoomable/3D perspective (spherical Earth)
- Ground/orbit tracks for each satellites with general symbol ID
- Sensor ground swaths/
- Ground station coverage contours with general symbol ID
- Sensor view window
- Animated graphics in simulation
- Display solar terminator conditions

FEATURES:
- During simulation - can change view direction, viewpoint position
- Viewpoint types: inertial fixed point in space, satellite, or site based
- Simulation status parameters available in status windows

OrbitWin

CONTACT:

Microcosm Discount Astronautics Software (Distributors)
2377 Crenshaw Blvd., Suite 300
Torrance, CA 90501
(310) 320-0555
(310) 320-0252 fax

- Ephemeris and event prediction for Earth orbiting satellites, space probes, reentry vehicles, and lunar and solar bodies

PURCHASE INFORMATION:

- $895 (Upgrade from OrbitWin 3.x is $195)

SYSTEM REQUIREMENTS:

- PC with Microsoft® Windows™ 95 or NT, math coprocessor

SOFTWARE STRUCTURE/SUPPORT:

- On-line help

UNITS:

- Can convert values

PROPAGATOR:

- Runge-Kutta-Shanks 8th order numerical integrator with twelve stages

PERTURBATIONS:

- Geopotential models (up to degree 12)
- Atmospheric drag (cubic spline log density profile)
- Solar radiation pressure (only in OrbitWin 95)
- Solar/lunar effects

OUTPUT CONTENT:

- Geodetic, spherical, radar, and rectangular coordinates of satellite, Sun, and Moon

ANALYSES:

- Lunar and Solar eclipse events, as well as aspect, elevation, and elongation angles relative to satellite are computed

GRAPHICS:

- Satellite ground tracks
- Sensor field-of-view swaths
- Tracking station equidistant contours
- Station pass azimuth-elevation views

FEATURES:

- Key events during satellite orbit are detected and displayed on an event timeline

Orbit Works

CONTACT:

ARSoftware
S. W. Khalsa
8201 Corporate Drive Suite 1110
Landover, MD 20785
(800) 257-0073
FAX: (301) 459-3776
Jim Farrel
S/W Developer
1867 Park Rd NW
Washington DC 20010
(202) 232-1441

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $595
- Purchase options: Included but optional modules: Earth Observation Analysis Tools/Spacecraft-Spacecraft Analysis Tools/Spacecraft-Suborbital Trajectory Analysis Tools

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Number of sites limited to 12 per simulation/satellite limited to 36 per simulation/total number of orbit revolutions per satellite limited to 2,500 per simulation
- Interfaces with external programs: Ridge Technology software converting osculating element sets to NORAD element sets

INPUT:

- GUI interactive menu
- Can load sites/satellites from database
- Constellation input (set initial sat and # planes and # sats)
- Ballistic input: initial element set with all information needed to calculate vehicle acceleration throughout trajectory (GCF initial conditions at burnout - latitude, longitude, altitude, velocity, flight path angle, azimuth)

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines/2D bar charts)

UNITS:

- Angle: degree

ELEMENT TYPES:

- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Analytical propagator: SGP4
- Tabular close approach determination

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation

PLANETARY:

- Sun position
- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Time history of latitude/longitude/altitude/cosine of solar zenith angle
- Element set from propagator
- Visibility azimuth/elevation/ranges between site/satellite or satellite/target
- Visibility azimuth/elevation/range/range-rate (nm/s only) between satellite/satellite
- Output can be limited to time of constraint satisfaction (minimum/maximum range/minimum duration)
- Constraint satisfaction summary profile (average length/average gap/minimum length/maximum gap/maximum length/# occurrences/% time)
- Sun rise/set times (determined by separate algorithm)
- Object in sunlight (plots local solar time (sun relative right ascension at the boresight intersection with the specified altitude) vs. latitude by revolution with each a different color up to seven colors then repeats)

ANALYSES:
- Multi-site/satellite simulation
- Ground coverage analysis (display station passes and availability by spacecraft)

GROUND SITES:
- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation/azimuth/range (minimum/maximum)

SENSOR OPTIONS:
- Define sensor cone with elevation
- Set pointing constraints: nadir pointing/fixed with respect to vehicle/aimed at horizon at specified latitude/instrument observation altitude
- Can define complex systems of constraints between sites/satellites (pass duration/sun elevation/concurrent visibility at second site)
- Allows sun constraints for sensors

TARGETS:
- Can create areas of interest used in visibility analysis (up to eight sided polygon)
- Ships/ground vehicles/airplanes (through series of time and positions with all functions of fixed sites/course and speed for each track leg with concurrent access to ground station)

GRAPHICS:
- Maps: zoomable/Mercator/3D perspective (spherical Earth)/North Pole view
- Ground track (only during time of contact)/orbit tracks for each satellite/target with general symbol ID
- Sensor ground swaths/instantaneous sensor footprint
- Sensor view window (displays instrument scan pixel by pixel from horizon to horizon - FOV is square aperture in milliradians - current roll-pitch-yaw settings are ignored
- Display solar terminator conditions/solar sub-point

FEATURES:
- Graphic timeline/schedule of activities/events (Histograms of operations and gap times/Time bar plots of operations -single vehicle and composite time bar)
- Map display of instrument activation (for system operations)
- Computes ground resolution and image line length using slant range, effective focal length, detector spacing, and number of pixels
- Orbit synthesis - geostationary, Molniya, and sun synchronous
- Computes the required off-nadir elevation angle for given orbit and observed phenomena altitude (i.e. earth atmospheric limb)
- Can convert passes to format used by operations analysis in Orbit Works
- Spacecraft coordinate system defined in LVLH centered at spacecraft center of gravity (point mass)

USERS:
- NOAA/GOEs/SATS/UARS/EOS/TDRSS/GPS/SSBUV/ATLAS

CONCERNS:

- Number of sites limited to 12 per simulation/number of satellites limited to 36 per simulation/number of revolutions limited to 2,500 per simulation

OrbSim2

CONTACT:

GAO Associates
22 Warburton Way
Northampton, MA 01060-1657
(413) 586-3999
(413) 586-9799 fax

- Comprehensive mission analysis

PURCHASE INFORMATION:
- Cost: $495

SYSTEM REQUIREMENTS:
- PC

SOFTWARE STRUCTURE/SUPPORT:
- Number of satellites limited to nine per simulation
- INPUT:
- Can load satellites from database
- Database of sites (NASA/NORAD)/satellites available with software

OUTPUT FORMAT:
- ASCII/text data

ELEMENT TYPES:
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:
- Analytical propagator

PERTURBATIONS:
- Geopotential: J5

PLANETARY:
- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:
- Visibility azimuth/elevation/range/range-rate/s between site/satellite
- Visibility range/range-rate/direction cosines between satellite/satellite
- Output can be limited to time of constraint satisfaction (relay site/satellite)
- Object in sunlight

ANALYSES:
- Multi-site/satellite simulation
- Ground coverage analysis

GROUND SITES:
- Defined by latitude/longitude/altitude

GRAPHICS:
- Maps: Mercator
- Ground tracks for each satellites
- Earth coverage contours
- Visibility between site/satellite or satellite/satellite (2D)
- Sensor view window
- Display solar terminator conditions

FEATURES:
- Element set filter: through NORAD ID # or user created

CONCERNS:
- Number of satellites limited to nine per simulation

Orion

CONTACT:

Kisak-Kellogg Inc. (KKI)
Paul Kisak
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (540) 869-0554
E-mail: kki@visuallink.com

- Comprehensive mission analysis

PURCHASE INFORMATION:

- Cost: $5,900
- Purchase includes: executable and source code
- Purchase options: volume discounts: 2-5 copies: $3,170/12-20 copies: $1,450/30-50 copies: $953/65-100 copies: $575/more than 120 copies: $452

SYSTEM REQUIREMENTS:

- 80386 or higher PC
- Operating system: MS-DOS® 5 or higher and Microsoft® Windows 3.1 or higher
- RAM: 1 MB
- Hard Drive Space: Source Code - 15 MB; Executable - 700 KB; Data files - 3 MB
- Media Format: 3.5" disks/5.25" disks/modem

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/C/C++/Assembler/BASIC with double precision
- Open structure - modifications easy/designed to be portable/supports multiple networked users (through DLL)
- Source code available
- Documentation available with technical/user information
- Software verified against NRL real time validation/Fort Meade real time validation/NASA-Goddard verification & validation/NASA-Ames verification & validation/Hughes verification & validation/ALCATEL verification & validation/CIA verification & validation/academic standards from Escobal
- Support group available
- On-line help (real-time hypertext help and manual)
- Number of sites/satellites limited only by memory
- Accuracy of 1 part in 100 million iteration

INPUT:

- GUI interactive menu
- Can load sites/satellites from database
- Can save/load whole scenario/configuration (scenario scripting)
- Constellation input (Walker elliptical/geostationary/composite system - set initial sat and # planes and # sats)

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time
- Real-time data processing
- Simulation playback (with scenario scripting)

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

- Screen plot (2D lines)

CONVERSION/TRANSFER:

- Between element sets: Cartesian position and velocity/Classical/NORAD 2-line and vice versa
- General coordinate transformations (mean to osculating and vice versa)

UNITS:

- Distance: AU (astronomical unit-Earth-Sun mean distance)/DU (distance unit - Earth Radii)/yards/nautical miles/statute miles/kilometers/meters (input/output)
- Angle: radian/degree (input/output)
- Time: Calendar date/Hours (for any time zone)/Minutes/Seconds/Julian Date/UT
- Mass: Pound/kilogram/gram/ounce
- Can convert values
- Internal Units: second/meter/radian

ELEMENT TYPES:

- Mean/Osculating Classical Keplerian (input/output)
- Mean/Osculating Earth Centered Inertial position and velocity (input/output)
- Mean/Osculating Earth Centered Earth Fixed position and velocity (input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Numerical propagator with Runge-Kutta 4th order
- Analytical propagator: F&G (planetary propagation)
- Can limit to two body
- Coordinate system: Earth true equator mean equinox of 1Jan2000.00:00:00 (with/without oblateness corrections) (input/output)/Earth true equator true equinox of 1Jan2000.00:00:00 (with/without oblateness corrections) (input/output in)/heliocentric (input/output)/barycentric (input/output)
- Maximum altitude => 36,000 km
- Minimum altitude = 0 km
- Can simulate rectilinear orbits

PERTURBATIONS:

- Geopotential: none/WGS-84 (12x12)/GRS-80 (12x12)/user defined
- Atmospheric drag: Static Modified Harris-Priester
- Earth albedo (not usually provided)/relativistic effects (not seamless)
- Central body replacement for extra-terrestrial orbits
- Spacecraft modeling: mass/drag coefficients/can separate multiple sensor or payload definitions and models
- Engine thrusters (not seamless)

ORBIT MANEUVERS:

- Finite burns

PLANETARY:

- Sun/Moon/planetary positions and velocities (F&G propagator and JPL-L-T normalized algorithm)
- Predicts Earth/Lunar eclipses (conical shadow modeling)
- Star catalogue (includes stellar objects - galaxies, meteor showers, nebulae, etc.)
- Planetary ephemeris origin: Table/propagation JPL-LTN
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Allows replacement of central body with user identified planet for orbit simulation

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Time history of latitude/longitude/equator crossing times/longitude of ascending node/altitude/apogee/perigee
- Element set from propagator

- Visibility azimuth/elevation/range/range-rate site/satellite, site/target, satellite/satellite, and satellite/target
- Lifetime analysis/re-entry predict (analytic)
- Atmospheric compensation

ANALYSES:

- Multi-site/satellite simulation
- Ground coverage analysis

GROUND SITES:

- Defined by latitude/longitude/altitude/local time
- Ground sensor defined by elevation

SENSOR OPTIONS:

- Define sensor cone with elevation (minimum/maximum)/azimuth (minimum/maximum)/antenna parameters
- Set pointing constraints: nadir pointing/fixed with respect to vehicle
- Can define multiple sensors per satellite
- Additional sensor patterns: rectangular/square/elliptical/wide area/annular

GRAPHICS:

- Maps: zoomable/Mercator/3D perspective (inertial or rotating spherical Earth)/North Pole view/point interrogation
- Maps show coastlines/islands
- Save to file/Print to color/laser printer
- Ground/orbit tracks for each satellite with general symbol ID
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours with general symbol ID
- Sensor view window
- Animated graphics in simulation
- Display solar terminator conditions

FEATURES:

- Participated in Orbit Propagator Software Survey
- Full clipboard capability
- Instant access to all internal variables, data and relative plotting
- Payload modeling: vidicon or camera, infrared passive/active, synthetic aperture radar (SAR), radar, boresight pointing or alignment, half-angle beam widths, various antenna patterns and ancillary support (push broom, annulus SAR, spotlight beams, wide area coverage beams, swaths)

CONCERNS:

- Does not recognize when impact Earth

OSMEAN

CONTACT:

NASA Center for Aerospace Information
Manager Technology Transfer Office
800 Elkridge Landing Rd
Linthicum Heights, MD 21090-9908
TSP # 39
Written by Bruce Shapiro, Caltech
NASA Cosmic
Cosmic Order #NPO-18741 (DEC VAX)
or NPO-18796 (HP9000)
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Orbit element conversion program

PURCHASE INFORMATION

- Cost: free
- Cost to non-government: $1,300 + $16 documentation

SYSTEM REQUIREMENTS:

- DEC VAX/HP9000
- Operating system: VMS/HP UX
- Media Format: .25 inch streaming magnetic tape cartridge in IOTAMAT format (HP9000)/3.5 inch disk in UNIX tar format (HP9000)/DEC VAX BACKUP format on TK50 tape cartridge (DEC VAX)

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77

CONVERSION/TRANSFER:

- General coordinate transformations (mean to osculating and vice versa)

PERTURBATIONS:

- Geopotential: J2
- Lunar/solar body effects

FEATURES:

- Sample input/output given

CONCERNS:

- Not a complete orbit analysis package

OTIS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Orbit maneuver simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Cyber

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

ORBIT MANEUVERS:

- Calculates time of flight and velocity needed for transfer between two orbits
- Can optimize for fuel efficiency

ANALYSES:

- Optimization through iteration

CONCERNS:

- Not a complete orbit analysis package
- Not for external distribution

Propagation and Line of Sight (PALOS)

CONTACT:

The Aerospace Corporation
Don M Konold
2350 East El Segundo Blvd.
El Segundo CA 90245-4691
PO Box 92957
Los Angeles CA 90009-2957
(310) 336-6453
FAX: (310) 336-1989
E-mail: konold@courier3.aero.org

- Line of sight and orbit propagator simulation

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $100

SYSTEM REQUIREMENTS:

- PC
- Operating system: MS-DOS®
- RAM: 8 MB
- Hard Drive Space: Executable - 5 MB; Data files - 1 MB
- Media Format: 3.25 inch disks

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Documentation available with technical/user information
- Software verified against various mission support (M0/M2/shuttle STS-39, STS-53, etc.)
- Number of satellites limited to one per simulation

INPUT:

- Namelist input
- Column formatted file
- Keyboard prompted

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

UNITS:

- Distance: feet/nautical miles/kilometers
- Angle: radian/degree
- Time: Hours/Minutes/Seconds
- Internal Units: DU (distance unit - Earth Radii)/radian/second

ELEMENT TYPES:

- Mean Classical Keplerian (input/output)
- Earth Centered Inertial position and velocity (input/output)
- Earth Centered Earth Fixed position and velocity(input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Numerical Runge-Kutta 7-8th order
- Analytical propagator: SGP4
- Coordinate system: Earth true equator true equinox of date (input/output/internal)/Earth mean equator mean equinox of 1JAN2000.00:00:00 (input/output)/M1950 (input/output)
- Maximum altitude = 36,000 kilometers

- Minimum altitude = 100 kilometers

PERTURBATIONS:

- Geopotential: WGS-84 J2/J3
- Atmospheric drag: Time varying Jacchia 1971
- Solar radiation pressure with cylindrical shadow modeling
- Earth albedo/relativistic effects
- Spacecraft modeling: mass/drag coefficient/cross-sectional area/spacecraft dimensions
- Vehicle attitude: 3DOF table input
- Engine thrusters

ORBIT MANEUVERS:

- Impulse/Finite (low thrust electric propulsion) burns
- input thrust vector in spacecraft coordinate frame (intrack/radial/crosstrack components)
- Tracks fuel expenditure

PLANETARY:

- Sun/Moon positions and velocities
- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Time history of beta angle
- Element set from propagator
- Visibility azimuth/elevation between satellite/Earth limb, satellite/sun, satellite/velocity vector, satellite/moon
- Object in sunlight

GROUND SITES:

- Defined by latitude/longitude/altitude
- Ground sensor defined by elevation/azimuth/range (maximum)

FEATURES:

- Warning when go below 100 km and terminate when hit mean Earth
- Attitude (LVLH, ECI, fix on inertial body, thruster or attitude hold) input through table, also have attitude hold deadband for attitude accuracy and fuel consumption - attitude through (pitch/yaw/roll)
- Provides model of STEP spacecraft solar array sun capturing (maximizes sunlight on arrays and adjusts yaw to preclude shadowing by satellite body) and Shuttle simulations
- Can simulate solar array shadowing
- User input or simulated 11 year average input of F10.7 and Ap

CONCERNS:

- Not a complete orbit analysis package
- Number of satellites limited to one per simulation
- Time start simulation and epoch of state vector must match

PCOrbit (Orbital Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Orbit propagator

PURCHASE INFORMATION:

- Cost: $540
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

PROPAGATOR:

- Numerical Nystrom 4th order integrator

PERTURBATIONS:

- Geopotential: (12x12)
- Atmospheric drag: Time varying Modified Harris-Priester

OUTPUT CONTENT:

- Time history of latitude/longitude

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Satvis Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Site/satellite visibility

PURCHASE INFORMATION:

- Cost: $4,900
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine
- Screen plot (2D lines)

PLANETARY:

- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Time history of latitude/longitude
- Visibility azimuth/azimuth-rate/elevation/elevation-rate/range/topocentric right ascension and declination between site/satellite
- Sun rise/set times
- Object in sunlight

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (GNC Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Orbit plane guidance, navigation, and control

PURCHASE INFORMATION:

- Cost: $4,940
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

ELEMENT TYPES:

- Osculating Classical Keplerian (output)
- Osculating Earth Centered Inertial position and velocity (output)

PERTURBATIONS:

- Spacecraft modeling: mass (spacecraft/propellant)
- Engine thrusters

ATTITUDE DETERMINATION:

- Spin/3-axis stabilized modeled

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns
- Simulates stationkeeping maneuvers
- Pre-set burn/coast times
- Tracks fuel expenditure
- Estimate thruster performance/trend information

OUTPUT CONTENT:

- Element set from propagator

FEATURES:

- Inputs include: ignition model, thrust model, burnout times, maximum thrust, sustained thrust and specific impulse.

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Synch Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Sun synchronous orbit synthesis

PURCHASE INFORMATION:

- Cost: $1,390
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

FEATURES:

- Calculates required inclination for sun synchronous orbit

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Shadow Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Satellite shadow condition simulation

PURCHASE INFORMATION:

- Cost: $2,750
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

PLANETARY:

- Sun/Moon positions
- Predicts Earth/Lunar eclipses

OUTPUT CONTENT:

- Visibility plane angle/phase angle between satellite/sun
- Sun rise/set times
- Object in sunlight

FEATURES:

- Solves the quartic equation to determine umbra and penumbra conditions

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Delta V Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Orbit transfer maneuver simulation

PURCHASE INFORMATION:

- Cost: $2,900
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

PERTURBATIONS:

- Spacecraft modeling: mass
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns
- Calculates time of flight and velocity needed for Hohmann/one tangent/bi-elliptic burn transfer between two orbits
- Tracks fuel expenditure

OUTPUT CONTENT:

- Time history of velocity/mass/maneuvers/apogee/perigee/transfer orbit specifics

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Transfer Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Orbit transfer maneuver simulation

PURCHASE INFORMATION:

- Cost: $4,600
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

PERTURBATIONS:

- Spacecraft modeling: mass
- Engine thrusters

ORBIT MANEUVERS:

- Impulse burns
- Calculates time of flight and velocity needed for Hohmann/one tangent/bi-elliptic burn transfer between two orbits
- Tracks fuel expenditure

OUTPUT CONTENT:

- Time history of initial/transfer/final orbit specifics

FEATURES:

- Models out of plane maneuvers 9change in inclination)

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Revisit Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Repeat ground track orbit synthesis

PURCHASE INFORMATION:

- Cost: $1,240
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

PERTURBATIONS:

- Geopotential: J2

FEATURES:

- Orbit synthesis for repeat ground track requirements
- Calculates: semi-major axis/perigee/apogee/fundamental interval/nodal perturbation/nodal period/Keplerian period

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Geodetic Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Position calculation

PURCHASE INFORMATION:

- Cost: $2,210
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

FEATURES:

- Calculates: geodetic latitude/geocentric declination/geocentric distance/geodetic altitude

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Rates Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Rate of change of true anomaly

PURCHASE INFORMATION:

- Cost: $2,285
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

OUTPUT FORMAT:

- Screen plot (2D lines)

FEATURES:

- Determines the orbital time rate of change of true anomaly/acceleration of true anomaly/plots these values as a function of true anomaly

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Coverage Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Earth coverage simulation

PURCHASE INFORMATION:

- Cost: $2,235
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

ANALYSES:

- Ground coverage analysis

SENSOR OPTIONS:

- Define sensor cone with elevation

FEATURES:

- Determines the maximum percentage of Earth coverage

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Lifetime Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Lifetime simulation

PURCHASE INFORMATION:

- Cost: $2,720
- Purchase includes: executable and source code

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Source code available

OUTPUT CONTENT:

- Lifetime analysis/re-entry predict

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Optical Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Communications analysis

PURCHASE INFORMATION:

- Cost: $255

SYSTEM REQUIREMENTS:

- PC

FEATURES:

- Analyzes optical and near-infrared communication links which use pulse position modulation (PPM) and direct detection

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (AFC Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Automatic frequency control simulation

PURCHASE INFORMATION:

- Cost: $55

SYSTEM REQUIREMENTS:

- PC

FEATURES:

- Simulates the Automatic Frequency Control subsystem of a DMSK (Differential Minimum Shift Keying) receiver
- Generates the bit number/frequency error for the bit
- Computes mean and standard deviation of the frequency error

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Interference Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Frequency interference simulation

PURCHASE INFORMATION:

- Cost: $175

SYSTEM REQUIREMENTS:

- PC

OUTPUT FORMAT:

- Screen plot (2D histogram)

FEATURES:

- Quantifies the interference that is experienced by a ground station due to an interfering satellite
- Both the target/interfering satellites are assumed to be in elliptical orbits
- Doppler effects due to satellite motion/Earth's rotation are modeled
- Effect of the interfering satellite signal modulation/Doppler effect on the power received are considered
- Statistical formulation of the interference effect is presented in the form of a histogram of the interference to the desired signal power ratio

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Rendev Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- On-orbit mission planning tool

PURCHASE INFORMATION:

- Cost: $55

SYSTEM REQUIREMENTS:

- PC

RUN-TIME OPTIONS:

- Simulation runs in real-time

ELEMENT TYPES:

- Osculating Earth Centered Inertial position and velocity (output)

ORBIT MANEUVERS:

- Impulse burns

OUTPUT CONTENT:

- Element set from propagator
- Sensor view window (forward looking only)

FEATURES:

- Resulting trajectory is then plotted.

CONCERNS:

- Not a complete orbit analysis package

PCOrbit (Rain Module)

CONTACT:

Kisak-Kellogg Inc. (KKI)
Suite 100
1011 Chapel Road
Middletown, VA 22645
(703) 247-4333
FAX: (703) 869-0554
Paul Kisak

- Rain attenuation model

PURCHASE INFORMATION:

- Cost: $55

SYSTEM REQUIREMENTS:

- PC

OUTPUT CONTENT:

- Rain attenuation

FEATURES:

- Static and dynamic statistical assessment of the impact of rain attenuation on a communications link (1 to 1000 GHz) between site/geosynchronous satellite

CONCERNS:

- Not a complete orbit analysis package

PC Satellite Orbit Analysis Program (SOAP) v8.1

CONTACT:

The Aerospace Corp.
Gina D. Galasso
Dave Stodden
Mail Station M1/177
PO Box 92957
Los Angeles CA 90245-2957
(310) 336-7991, 7992
Sharon Robinson (distribution)
(310) 336-7000

- Comprehensive mission analysis

PURCHASE INFORMATION

- Cost: free
- Cost to non-government: approx. $100
- Future developments: coordinate frame transfer routines/lunar missions/Earth impact support/maintenance burns/communications support (signal to noise ratio, reflected power, path loss)/perturbations (J4, Jacchia-Walker atmosphere, solar/lunar effects, lunar trajectories)

SYSTEM REQUIREMENTS:

- 80386 or higher PC/Macintosh/Sun/Next workstations

SOFTWARE STRUCTURE/SUPPORT:

- Written in C/C++
- Open structure - modifications easy/designed to be portable
- Documentation available with user information
- Support group available
- On-line help
- Number of satellites/targets limited to 400 per simulation (PC/Macintosh)
- Number of sites limited to 400 per simulation (PC/Macintosh)
- Number of satellites/targets limited to 2,000 per simulation (Sun)
- Number of sites limited to 2,000 per simulation (Sun)
- Interfaces with external programs: model launch vehicle through input from external launch generator with time tagged R & V in ECI/

INPUT:

- GUI interactive menu
- Can load sites/vehicles/targets from database
- Can accept propagator input from external program
- Database of sites/vehicles/targets available with software
- Can save/load whole scenario/configuration
- Constellation input (Walker system - set initial sat and # planes and # sats)

RUN-TIME OPTIONS:

- Quit/pause/return to original epoch
- Simulation runs in accelerated/real-time (can accept input from system clock)
- Real-time data processing
- Simulation playback

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines)

UNITS:

- Distance: DU (distance unit - Earth Radii)/feet/nautical miles/kilometers/meters
- Time: Calendar date/Hours/Minutes/Seconds

ELEMENT TYPES:

- Osculating Classical Keplerian (input/output)
- Osculating Modified Keplerian (input/output)
- Osculating F&G (input/output)
- Osculating Earth Centered Inertial position and velocity (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (input/output)
- (Mean/Osculating) geoclassical (input/output) (latitude/longitude/inclination/argument of perigee/perigee altitude/apogee altitude)
- (Mean/Osculating) neoclassical (input/output) (latitude/longitude/inclination/argument of perigee/semi-major axis/eccentricity)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:

- Numerical propagator
- Tabular close approach determination (though exclusion range in satellite sensor)

PERTURBATIONS:

- Geopotential: J2
- Spacecraft modeling: mass/spacecraft dimensions/can separate satellite into main body and panel component areas
- Vehicle attitude: 3DOF
- Engine thrusters

ATTITUDE DETERMINATION:

- Spin/3-axis stabilized/nadir pointing/sensor pointing/user defined yaw, pitch, and roll modeled

ORBIT MANEUVERS:

- Coast/Impulse/Finite (simulated with repeated impulsive - full finite burn model in future) burns
- Input thrust vector in spacecraft/inertial coordinate frame
- Calculates time of flight and velocity needed for Hohmann transfer between two orbits
- Pre-set burn/coast times

PLANETARY:

- Sun/Moon positions and velocities
- Predicts Earth/Lunar eclipses
- Star catalogue

OUTPUT CONTENT:

- Save to file/Print to color/laser printer
- Element set from propagator
- Visibility azimuth/elevation/range between site/satellite, satellite/satellite, satellite/target, and site/target

ANALYSES:

- Multi-site/satellite/target simulation
- Monte Carlo dispersion analysis/graphics show probability distributions
- Ground coverage analysis

GROUND SITES:

- Defined by latitude/longitude/altitude/ID (text)
- Ground sensor defined by elevation (min/max)/azimuth (min/max)/range (min/max)

SENSOR OPTIONS:

- Define sensor cone with elevation (min/max)/azimuth (min/max)/range (min/max)/antenna parameters
- Set pointing constraints: nadir pointing/fixed with respect to vehicle/fixed with respect to inertial frame/aimed at point on Earth/sun track/sweep and ground pendulum angle
- Can define complex systems of sensors/constraints with and/or/not/at least between sites/vehicles/targets

- Additional sensor patterns (through overlap of conical sensors)
- Allows sun/ram (into velocity vector) constraints for sensors

TARGETS:

- Ships/ground vehicles/airplanes (supports great circle/oval/figure eight tracks)

GRAPHICS:

- Maps: zoomable/Mercator/3D perspective (spherical Earth)/North Pole view/
- Maps show coastlines/islands/countries/states/lakes/rivers
- Save to file/Print to color/laser printer
- Ground/orbit tracks for all satellites/missiles with unique text/symbol ID
- Sensor ground swaths/instantaneous sensor footprint
- Ground station coverage contours with unique text/symbol ID
- Visibility with site/vehicle/target (2D/3D)
- Sensor view window
- Sensor 3D cone
- Animated graphics in simulation
- 3D vehicle structure definition
- View vehicle attitude

FEATURES:

- Partial user modifications through scripting language
- Read print file into WordPerfect, HPIII LaserJet, PostScript, HPGL
- Visibility can be set to inclusion (meet Az/El/Range) or Exclusion (meet range only: could be used for LOS and collision avoidance)
- Can create replay file for certain scenarios for demonstration without keyboard interaction
- Can pitch solar panels or track the sun
- Ground sensors can be gimbaled, track objects and have altitude
- Determines 1 and 2 way links between satellites
- Can change output to windows during run
- Split screen up to four separate views
- Has Az/El grid for ground to space viewing

CONCERNS:

- Number of sites limited to 400 (PC/Macintosh) or 2,000 (Sun)
- Number of satellites/targets limited to 400 (PC/Macintosh) or 2,000 (Sun)

Probabilistic Evaluation of Risk for Collisions Tool (PERFCT)

CONTACT:

The Aerospace Corp.
Deanna Maines
M4-947
(310) 336-8570
deanna.maines@aero.org
PO Box 92957
Los Angeles CA 90245-2957

- Computes probability of collision between two objects (satellite vs. Satellite, or satellite vs. launch vehicle) with a known close approach

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- Hosted on SUN workstations

SOFTWARE STRUCTURE/SUPPORT:

- Written in C

ANALYSES:

- Probability of collision
- Debris analysis

FEATURES:

- Utilizes knowledge of positional uncertainties of the two objects to compute the collision probability

CONCERNS:

- Not a complete orbit analysis package

PLAN-IT-II

CONTACT:

Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109
Sven Grenander
MS 301-250D
(818) 354-0156

- Timeliner and conflict resolution

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC

FEATURES:

- Continuously updated
- Graphic timeline/schedule of activities/events
- Spread-sheet approach to sequence integration and conflict detection/ resolution
- Spot conflicts
- Multiple levels of abstraction/detail - consistency is automatically maintained
- Graphically edit timeline
- Manually edit timeline activity intervals
- Manual & automatic edit of MACROS
- Complex 'intelligent' MACROS
- ADAPT function is part of the tool - high level language, edit timeline layout, edit models, rules guidelines and resources

CONCERNS:

- Not a complete orbit analysis package
- Limited external distribution

Portable Interactive Troubleshooter (POINTER)

CONTACT:

ARINC Inc.
1925 Aerotech Dr. Suite 212
Colorado Springs, CO 80916
Frank Johnson
(719) 574-9001

- Fault diagnosis aid with integrated maintenance system approach

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC or embedded

Interfaces with external programs: embedded within or call other programs

SOFTWARE STRUCTURE/SUPPORT:

- Open structure - modifications easy/designed to be portable
- Source code available

FEATURES:

- Model based system records logistical data: component failure rates and fault isolation times
- Does not use static fault trees - does compute the optimum fault isolation strategy at each test step based on problem context
- Can learn from experience in test diagnosis and apply to optimize future maintenance activities
- Improves diagnostic capability of field technicians
- Decreases skill level requirements
- Reduces down time through improved diagnostic accuracy
- Reduces maintenance costs
- Provides training of technicians though a comprehensive 'explain' facility
- Knowledge base - developed using STAMP - test information flow model is input
- Develops optimum test sequence for diagnosing system failures
- Hypothesize option allow user to make best guess about component causing failure - POINTER then selects optimal test sequence to verify or deny hypothesis
- Test Override: option allows user to select test other than program recommended
- Test Delay and Test Untestable options allow the user to delay a test or declare it unavailable or untestable
- Explain function gives a detailed explanation of the current state of fault isolation as well as analyses of options available to user
- Learning: under the information theoretic approach, weighting factors (component failure rates/test times/technician skill levels) can be used to influence test strategy - automatically collects and updates component failure rates and test times as diagnoses are performed and may change test strategy over time using this experience
- Applied to more than 50 systems: analog electric, digital electric, analog/digital hybrid, mechanical, hydraulic, electromechanical, pneumatic, electrochemical, fluid and process, and electrohydraulic

CONCERNS:

- Not a complete orbit analysis package

POST/6D POST

CONTACT:
NASA & Lockheed Missiles and Space Co
Cosmic Order #LAR-14869 (SGI) or LAR-14871 (SUN)
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- 3 (POST) or 6 (6D POST) degree of freedom launch trajectory optimization

PURCHASE INFORMATION:
- Cost: free
- Cost to non-government: $5,000 + $163 or $138 documentation

SYSTEM REQUIREMENTS:
- Sun/SGI workstation

SOFTWARE STRUCTURE/SUPPORT:
- Written in FORTRAN
- Documentation available
- Tutorial and troubleshooting guide
- Number of vehicles limited to 900 per simulation

PROPAGATOR:
- Numerical propagator

PERTURBATIONS:
- Geopotential: J2
- Atmospheric drag
- Aeropotential models: pressure/speed of sound
- Side-force wind effects/buoyancy/lift
- Spacecraft modeling: mass/cross-sectional area/vehicle dimensions (airframe model)
- Vehicle attitude: 3DOF/6DOF/gimbal angles (calculated/user defined)/laminar flow/turbulent flow/aeroheating
- Engine thrusters

BALLISTIC/LAUNCH TRAJECTORY:
- 3/6DOF trajectory simulation and optimization
- 3D thrust control
- Throttle control (manual/autopilot)

ANALYSES:
- 3 DOF/6DOF (multi rigid body) vehicle dynamics simulation
- Optimization through iteration

CONCERNS:
- Not a complete orbit analysis package
- Number of vehicles limited to 900 per simulation

POWER

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Launch trajectory simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- PC

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation

ORBIT MANEUVERS:

- Finite burns

CONCERNS:

- Not a complete orbit analysis package
- No longer maintained by The Aerospace Corporation

Program for Rapid Earth-to-Space Trajectory Optimization (PRESTO)

CONTACT:

NASA & Lockheed Missiles and Space Co
Cosmic Order #LAR-10584
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Launch trajectory simulation and optimization

PURCHASE INFORMATION:

- Cost: free
- Cost to non-government: $500 + $34 documentation

SYSTEM REQUIREMENTS:

- CDC 6600

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN IV
- Documentation available

PERTURBATIONS:

- Central body replacement for extra-terrestrial orbits (Lunar/Mars/Venus)

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF trajectory simulation and optimization
- 3D thrust control/time of ignition & release/angle of attack/angle of yaw at each stage/coast time
- Launch azimuth modeled from ground
- Interstage coasting

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Allows interplanetary trajectory (heliocentric)
- Planetary escape/capture
- Interplanetary targeting
- Allows replacement of central body with user identified planet for orbit simulation (Lunar/Mars/Venus)

FEATURES:

- Closed-loop steepest descent optimization for flight trajectory for maximum booster payloads
- Earth launch to Earth orbit, Earth (orbit) launch to lunar orbit, Lunar landing from lunar orbit, Earth (orbit) launch to interplanetary transfer
- Up to 6 terminal constraints (Earth orbit and lunar landing), 2-3 on lunar transfer, 2 on interplanetary
- Terminal constraints on injection trajectory or orbit elements
- Intermediate optimization constraints - angle of attack, coast orbit perigee altitude, angle of attack and dynamic pressure product.

CONCERNS:

- Not a complete orbit analysis package

PSIMU v4.0

CONTACT:

CNES
18 avenue E. Belin
31055 Toulouse Cedex
France
61 28 16 78
61 27 35 40 fax
j.f.goester@hermes4.cst.cnes.fr

- Space mission operations and analysis software

PURCHASE INFORMATION:

- Currently only for internal use

SYSTEM REQUIREMENTS:

- Operating system: SunOS or SOLARIS

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77
- Useable as an executable program with or without GUI, as well as a FORTRAN 77 subroutine callable from other software

PROPAGATOR:

- Numerical Cowell adapted for orbit motion

PERTURBATIONS:

- Approximately 20 geopotential models (fidelity unknown)
- Atmospheric drag
- Solar-lunar effects
- Solar radiation pressure

ORBIT MANEUVERS:

- Impulsive/Finite burns

FEATURES:

- Participated in Orbit Propagator Software Survey

USERS:

- CNES

Rapid Orbit Prediction Program (ROPP)

CONTACT:

D.M. Wexler (author)
TRW Systems
Phillips Laboratory
Hanscom AFB, MA
Ed Robinson (contract manager)
(617) 377-3840

SYSTEM REQUIREMENTS:
- PC

SOFTWARE STRUCTURE/SUPPORT:
- Source code and executable available
- Written in FORTRAN 77 with double precision
- Documentation available with technical information

INPUT:
- Card deck equivalent file

UNITS:
- UT, kilometers, degrees

ELEMENT TYPES:
- (Mean/Osculating) Classical Keplerian (input/output)
- (Mean/Osculating) Earth Centered Inertial position and velocity (FK4/FK5) (input/output)
- Mean NORAD 2-line element set (input/output)

PROPAGATOR:
- Semi-analytic propagator

PERTURBATIONS:
- 5x5 geopotential (J2 osculating)
- Atmospheric drag with static and time varying exponential atmospheric model
- Jacchia 64 atmospheric model above 120km
- COESA 1962 atmospheric model below 120km
- Solar and lunar effects

ATTITUDE DETERMINATION:
- Mass, drag coefficient, cross sectional area spacecraft modeling

CONCERNS:
- Developed approximately 25 years ago
- Documentation not included with software
- 120km LEO minimum altitude
- Propagator type unknown

Rarefied Aerodynamics Modeling System for Earth Satellites (RAMSES)

CONTACT:

H. Klinkrad
Mission Analysis Section
ESA/ESOC
D-64293
Darmstadt, Germany
A. Schafer
Inst. fur Raumfahrttechnik
TU Munchen
D-80333
Munich, Germany

- Complex spacecraft vehicle definition

PURCHASE INFORMATION:

- Cost: unknown

PROPAGATOR:

- Semi-analytic integral technique

ANALYSES:

- Monte Carlo dispersion analysis

FEATURES:

- Interactive definition of geometry and surface properties of arbitrarily complex spacecraft
- Different surface interaction theories can be used to compute the aerodynamic coefficients of force and moment

CONCERNS:

- Not a complete orbit analysis package

Research and Development (RAND)

CONTACT:

Space Warfare Center/AE

- General purpose mission analysis

PURCHASE INFORMATION:

- Cost: unknown

PROPAGATOR:

- Tabular close approach determination

ORBIT DETERMINATION:

- Differential correction module

OUTPUT CONTENT:

- Element set from propagator
- Visibility azimuth/elevation between site/satellite
- Lifetime analysis/re-entry predict

CONCERNS:

- Not a complete orbit analysis package

REDUC

CONTACT:

United States Air Force
PL/VTS
Maj. David Vallado
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-4056

- Coordinate transformation software

PURCHASE INFORMATION

- Cost: free

SYSTEM REQUIREMENTS:

- PC

CONVERSION/TRANSFER:

- Between element sets: site latitude/longitude or ECEF position/velocity to J2000.0 position/velocity vectors
- Converts between Calendar date with time/LST/GST/Julian Date/Day of Year/UT1
- General time and coordinate transformations

CONCERNS:

- Not a complete orbit analysis package

RendezVous

CONTACT:

United States Air Force
PL/VTS
Maj. Dave Vallado
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-7990

- Optimize fuel for rendezvous/intercept simulation

PURCHASE INFORMATION:

- Cost: free

SYSTEM REQUIREMENTS:

- Any platform with FORTRAN compiler (tested on Macintosh/PC/Sun)
- Media Format: FTP/3.5" disk

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77 with double precision
- Source/object code available
- Documentation available with technical/user information
- Number of satellites limited to two per simulation (interceptor and target)

INPUT:

- Namelist-like input
- Column formatted file

OUTPUT FORMAT:

- ASCII data - exportable to external plot routine

PROPAGATOR:

- Numerical Cowell propagator with Runge-Kutta 4th order integrator
- Analytical propagator: two body/two body + J2
- Can limit to two body
- Can propagate forward/backward in time through integration

PERTURBATIONS:

- Geopotential: none/J2/J3/J4
- Atmospheric drag: Static exponential
- Solar radiation pressure with cylindrical shadow modeling
- Analytically propagated lunar/solar body effects

ORBIT MANEUVERS:

- Impulse burns
- Determines velocity needed to intercept target (Gauss Method - given R1, R2, Direction, Time of Flight)
- Determines velocity needed to rendezvous target (Hill Method)
- Can optimize for fuel efficiency
- Tracks fuel expenditure

ANALYSES:

- Optimization through iteration

FEATURES:

- Option 1: The user supplies the orbital elements for the satellite at a particular epoch and the magnitude, direction, and time of maneuvers that cause the satellite to deviate from the original element set. The new element set becomes the interceptor vehicle. The program will then give the required two burn sequence to return to the original element set.

- Option 2: The user supplies the interceptor orbital elements at a particular epoch and the target orbital elements at a particular epoch.
- In either option, the program determines the possible two-burn maneuvers that will rendezvous or intercept the target satellite within a user specified time frame.
- The total of the two burns is minimized to list the optimal time, magnitude and directions of the rendezvous burns. To consider intercept (not rendezvous) minimize only the first maneuver, not the total of both burns.

USERS:

- Phillips Laboratory

CONCERNS:

- Not a complete orbit analysis package
- Limited support group available
- Number of satellites limited to two
- Static program - no plans to update
- Requires external program for plotting

Real Time Orbit Determination (RTOD®)

CONTACT:

Logicon
Ned Stein
1350 Villa Street
Mountain View, CA 94041
(415) 965-7190
(415) 964-4618 fax
nstein@logicon.com

- High accuracy orbit propagation and orbit determination

PURCHASE INFORMATION:

- Basic licensing cost: $50,000 for first copy of RTOD, $15,000 for each additional copy used for same application at the same time (includes user's manual)
- Annual maintenance releases and limited telephone support is available after first year for 15% of license fee
- Engineering support purchase required to tailor RTOD to a specific application – approximately $120 / hour
- Specific modifications to the filter to handle unique orbital situations and provide extremely high accuracy are negotiated on a case by case basis.

SYSTEM REQUIREMENTS:

- 486/66 PC and higher
- Operating system: SCO/UNIX (or other UNIX)
- RAM: 32 MB
- Hard Drive Space: Source Code - 2 MB; Executable - 5 MB; Data files - 6 MB + 10 MB/day archive
- Media Format: FTP/Tapes

SOFTWARE STRUCTURE/SUPPORT:

- Written in C/C++ with double precision
- Documentation available with user information
- Software verified by US government agency (operational for classified project)
- Accuracy of: Maximum error within tracking contacts was 10 m and maximum error in tracking gaps was 40-50 m/One day predict error approx. 50-100 m

INPUT:

- GUI interactive menu

OUTPUT FORMAT:

- ASCII/text data
- Screen plot (2D lines - errors and residuals)

UNITS:

- Internal Units: minutes/Earth radii/radian

ELEMENT TYPES:

- Osculating Earth Centered Inertial position and velocity (FK5) (input/output)
- Osculating Earth Centered Earth Fixed position and velocity (FK5) (input/output)
- Osculating Classical Keplerian (input/output)
- Osculating equinoctial (input/output)

PROPAGATOR:

- Numerical Variation of Parameter propagator with Runge-Kutta 4th order integrator/Richardson extrapolation propagator with Burlisch-Stoer integrator
- Coordinate system: Earth true equator true equinox of J2000 (input - ECI/ECEF)/mean equator mean equinox of J2000 (output/internal - ECI/ECEF)

- Maximum altitude = > 36,000 km
- Minimum altitude = 0 km

PERTURBATIONS:

- Geopotential: GEM-10B (50x50)/JGM-2 (70x70)/WGS-84 (41x41)
- Atmospheric drag: CIRA 1972/Jacchia (1960)/Jacchia-Roberts (1971)
- Solar radiation pressure with conical shadow modeling
- 9th order Chebyshev lunar/solar/planetary body effects
- Earth tides (Love's equations)
- Spacecraft modeling: mass/drag coefficient/coefficient of reflectivity/cross-sectional area/spacecraft dimensions/can separate satellite into main body and panel component areas/Antenna offset from center of mass
- Engine thrusters

ORBIT DETERMINATION:

- Estimation: Extended Kalman filter
- Observation types: SGLS/Global Positioning System (GPS)
- Measurements: range/satellite-satellite range
- Solve for parameters: data error correction/residuals
- Real-time orbit determination

ORBIT MANEUVERS:

- Coast/Impulse/Finite burns

PLANETARY:

- Sun/Moon/planetary positions and velocities
- Predicts Earth/Lunar eclipses
- Planetary ephemeris origin: DE-200 JPL

OUTPUT CONTENT:

- Element set from propagator

ANALYSES:

- Multi-site/satellite simulation

GRAPHICS:

- Maps: Mercator
- Ground tracks for each satellite

FEATURES:

- Participated in Orbit Propagator Software Survey
- Includes CCS interface
- Can simulate multiple legged measurement paths (relays)
- Can process AFSCN SGLS range data in COBS format
- Simple to add modifications to output user specified alt/lon., perigee, apogee, height, etc.; input in Epoch 2000.0; Ephemeris differencing, ATA math library
- Plots radial, intrack, crosstrack 2 sigma error and measurement residuals with 3 sigma error bounds
- No preliminary orbit determination procedure (relies on launch range for that data)

REVISIT

CONTACT:

The Aerospace Corporation
Christopher Kobel
M4/948
(310) 336-7861
PO Box 92957
Los Angeles CA 90245-2957

- Multi-constellation, multi-sensor, multi-constraint coverage contouring program

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- Any platform with FORTRAN compiler
- Currently hosted on SUN workstations
- RAM requirements vary from 16 to 96 Mb

SOFTWARE STRUCTURE/SUPPORT:

- Approximately 8000 lines of 'plain vanilla' FORTRAN 77 (
- Requires Aerospace proprietary library ASTROLIB
- Documentation available with technical/user information

OUTPUT CONTENT:

- Typical output files vary from 1 to 12 Mb

ANALYSES:

- Ground coverage analysis

GRAPHICS:

- Contour plot outputs available through linking with PVWave or IDL graphics packages

FEATURES:

- Determines maximum and average revisit times, visibility intervals, and continuous coverage regions
- Executable in snapshot mode, single or multiple day cumulative mode, or it can be used to evaluate seasonal or annual effects
- Can be used to determine worst day solar outages, or to evaluate coverage performance variation during constellation buildup or degradation

USERS:

- Software used to support Space-Based Infra-Red System Summer Study, as well as concept analysis and mission planning exercises for MILSTAR

CONCERNS:

- Not a complete orbit analysis package

Satbase

CONTACT:

Space Flight Data Applications
Dr. A. Shukry
P.O. Box 195
NL-1740 Ad Schagen
The Netherlands
(+31) (0) 224 56 37 21
(+31) (0) 224 56 17 22 fax
a.shukry@inter.nl.net

- Spacecraft data analysis program with detailed spacecraft database

SYSTEM REQUIREMENTS:

- MS-DOS® compatible computer

SOFTWARE STRUCTURE/SUPPORT:

- Support group available
- Open structure - designed to be portable
- On-line help
- Documentation available with technical/user information

INPUT:

- Database of vehicles available with software
- Can accept propagator input from external program

RUN-TIME OPTIONS:

- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- ASCII/text data
- ASCII data - exportable to external plot routine

CONVERSION/TRANSFER:

- General time and coordinate transformations
- Between supported element sets

UNITS:

- Distance: feet/nautical miles/statute miles/kilometers/meters
- Angle: radian/degree/arcsecond
- Time: Calendar date/Hours (for any time zone)/Minutes/Seconds/GMT/LST/GST/Julian Date/Modified Julian Date/Day of Year/UT/UTC/UT1/TDT/TDB
- Mass: Lb./Kg

ELEMENT TYPES:

- (Mean/Osculating) Classical Keplerian (input/output)
- (Mean/Osculating) Earth Centered Inertial position and velocity (FK4/FK5) (input/output)
- (Mean/Osculating) Earth Centered Earth Fixed position and velocity (FK4/FK5) (input/output)
- Mean NORAD 2-line element set (input/output)
- (Mean/Osculating) equinoctial (input/output)
- (Mean/Osculating) geoclassical (input/output) (latitude/longitude/inclination/argument of perigee/perigee altitude/apogee altitude)

PROPAGATOR:

- Program does not recognize Earth impact
- Can propagate forward/backward in time through integration/interpolation

PERTURBATIONS:

- Two body propagator plus at least 12x12 geopotential (geopotential model unknown)

- Atmospheric drag
- Solar radiation pressure
- Solar, lunar, and planetary effects

BALLISTIC/LAUNCH TRAJECTORY:

- Launch window analysis
- Free-flight ballistic trajectory and thrusting trajectory models
- Aerodynamic coefficients provided

ORBIT MANEUVERS:

- Impulse/Finite burns
- Tracks fuel expenditure
- Calculates/simulates stationkeeping maneuvers
- Determines velocity needed to intercept target
- Determines velocity needed to rendezvous target
- Calculates time of flight and velocity needed for Hohmann transfers

OUTPUT CONTENT

- Lifetime analysis/re-entry predict

GROUND SITES:

- Defined by geodetic latitude/geocentric latitude/longitude/altitude

GRAPHICS:

- Ground/orbit tracks for each spacecraft on Mercator and rotating spherical Earth map
- Maps show coastlines
- Orbit traces for each spacecraft

FEATURES:

- Extensive database of launched, planned, decayed, and canceled worldwide unmanned spacecraft

CONCERNS:

- Unsure of propagator type (numerical/analytical)

Satellite-based Navigation Accuracy Performance Model v2.8(SNAPM)

CONTACT:

Dale Svenson (General Information)
Boeing North American
2800 Westminster Blvd.
PO BOX 3089
Seal Beach, CA 90740-2089
(310) 797-5256
dale.v.svenson@boeing.com
Andy Johnson (SNAPM Developer)
Director of Systems Requirements
Boeing North America Systems Development Center
(310) 797-3669
FAX: (310) 797-1469

- High fidelity simulation of space-based navigation system capabilities

PURCHASE INFORMATION

- cost free

SYSTEM REQUIREMENTS:

- SGI Indy/Indigo2 Extreme or better
- Minimum 32Mb RAM (64 Mb preferred, 128Mb optimal)
- Minimum 100Mb free disk space (>200Mb optimal)
- Media Format: FTP/.25" or 8 mm Tapes/DAT

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77/C/C++
- X-Windows used for GUI
- Object oriented design
- Open structure - modifications easy/designed to be portable/supports multiple networked users

RUN-TIME OPTIONS:

- Flexible tailoring of all simulation and display parameters
- Selective availability options

ELEMENT TYPES

- Navigation spacecraft (GPS, GLONASS, notional constellations)
- User equipment information (# of channels, satellite selection algorithms, differential capability, receiver noise)

PROPAGATOR:

- Error covariance matrix propagated with Kalman filter and 4th order Runge-Kutta

OUTPUT CONTENT:

- Information reporting in format readily usable by warfighter or navigation system analyst

ANALYSES:

- Variable timeframe accuracy pre-predict
- Overall availability predictions for specified accuracy levels

GROUND SITES:

- Specific user locations or computational grid region/area

GRAPHICS:

- Time history plots of accuracies/DOPs at specific user locations
- Animated graphical display of accuracy prediction (meters, DOPs) over a geographical area for a specified time window
- Satellite constellation overlays on geographical displays

- Plots of satellite providing nav solutions to user points over time
- Overall availability predictions for specified accuracy levels

FEATURES:

- Availability and accuracy prediction for military (Blue & Red Teams) and civilian users
- Navigation spacecraft (GPS, GLONASS, notional constellations)
- User equipment information (# channels, satellite selection algorithms, differential capability, receiver noise)
- Local area differential reference stations
- Wide area differential reference stations
- Earth based or geosynchronous differential communication nodes
- Pseudolites
- US military user (P-codes) accuracies in meters or DOPs
- Civilian or non-military user (C/A code) accuracies
- Local or wide area differential correction augmentation
- Pseudolite enhancements (pseudolites are GPS transmitters at known fixed ground sites)
- Selective or time dependent removal of navigation assets
- Selective availability options (enhancements in process)
- Atmospheric effects (ionosphere, troposphere)
- Local/Wide Area Differential reference stations
- Earth-based or geosynchronous differential communication nodes

CONCERNS:

- Not a complete orbit analysis package
- Future developments: Conversion to Pentium PC

Satellite Coverage Model (SCM)

CONTACT:

ARINC Inc.
1925 Aerotech Dr. Suite 212
Colorado Springs, CO 80916
Gary Nunn
(719) 574-9001

Comprehensive tool to modeling satellite constellations, mobile platform missions, and fixed ground sites

PURCHASE INFORMATION:

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- On-line help

INPUT:

- GUI interactive menu processing

OUTPUT CONTENT:

- Print to laser printer

GRAPHICS:

- Full screen, high resolution, color graphics
- High resolution (2km), zoomable world maps: Mercator and polar projections
- Up to 16 user selectable colors
- Print to laser printer
- Ground tracks for each satellite

FEATURES:

- Satellite antenna footprints
- Coverage over time by region: percentage of time covered by at least one satellite, number of satellites visible 100% of the time
- Mission plans including satellite handover points
- Locations of fixed sites
- Az-El plots for fixed sites
- Configuration save and customize features
- Screen files can be saved
- Security classification displayed on output

Satellite Management System (SMS) -

CONTACT:

ARINC Inc.
1925 Aerotech Dr. Suite 212
Colorado Springs, CO 80916
Bob Gagnon
(719) 574-9001

- UHF satellite communications control center software

PURCHASE INFORMATION:

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- On-line help
- Written in Structured Query Language (SQL) data base management system
- Designed in Ada and operates in Windows™
- Mouse driven menus and tool features

GRAPHICS:

- World map with satellite locations

FEATURES:

- Allocate and control satellite transponder assets
- Consolidates and automates complex scheduling processes and protocols tied to data bases of satellite system parameters and information on authorized users
- Performs scheduling and conflict resolution, updates the data bases, and simplifies generation of required responses and formatted messages to requesting users
- Provides executive-level and operator-level daily, monthly, and archival scheduling records
- Quick and accurate calculations of mission area satellite coverage and user look angles
- Automatic worksheets to enter request and resource data
- Supports wideband and narrowband UHF satellite users
- Produces charts, reports, and graphs of satellite configurations, anomalies, jamming and interference, daily/weekly/monthly scheduling, point-of-contact reports, preemption reports, system schedule and loading graphs
- Satellite orbital mechanics calculations
- Password protection
- Printed reports

USERS:

- Developed for Strategic Air Command

CONCERNS:

- Not a complete orbit analysis package - more scheduling

Satellite and Missile Analysis Tool (SMAT)

CONTACT:

USAF Space Warfare Center
SWC/AEW
720 Irwin Ave. Suite 2
Falcon AFB, CO 80912-7202
(719) 567-9247
Fax: (719) 567-9496

PURCHASE INFORMATION:
- Cost: free

SYSTEM REQUIREMENTS:
- SGI IRIX 5.3

SOFTWARE STRUCTURE/SUPPORT:
- Validated for accuracy of propagation and COMBO

INPUT:
- GUI interactive menu/batch processing
- Windows based user interface

OUTPUT FORMAT:
- Can print screen to file and save parameter sets

SENSOR OPTIONS:
- Site sensors and platforms with user definable geometries

TARGETS:
- ships/ground vehicles/airplanes

GRAPHICS:
- Maps show coastlines/islands/countries/states/lakes/rivers

FEATURES:
- Sensor coverage of missile corridors
- Coverage effects due to configuration or capability changes
- Visualizing complex relationships - tracking coverage, sensor FOV
- Capable of propagating NORAD Space Catalog
- 2D and 3D temporal and spatial data analysis for satellite, sensor, and missile coverage interactions
- Sun with accurate illumination
- Satellites: orbit traces, ground tracks, field of view cones, standard or user input element sets
- Computation of Miss Between Orbits - computes AZ/EL/Range/Range Rate between satellites
- Look Angle generation
- Lat./Lon of satellite sub-point
- Runs in TSC/SCI environment
- Enhanced version of KSAT
- In the process of being validated

CONCERNS:
- Releasable to government users only

Satellite Planning Decision Support System

CONTACT:

ARINC Inc.
1925 Aerotech Dr. Suite 212
Colorado Springs, CO 80916
Bob Gagnon
(719) 574-9001

UHF satellite communications planning tool

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- On-line help
- Menu driven through arrow keys or first-letter commands - pop up and data entry forms available where required

OUTPUT CONTENT:

- Generates multiple reports

ANALYSES:

- Analyzes user selectable and system problems to plan for disaster recovery

SENSOR OPTIONS:

- Calculates percent of daily visibility from each active satellite to all ground stations

FEATURES:

- Helps use communications assets effectively and rapidly configure satellite constellations in event of performance degradation or satellite failure
- Examine how variety of satellite problems and modified operating constraints affect coverage, connectivity, and throughput
- Generates coverage plan options with associated advantages/disadvantages accelerating the SATCOM repositioning process
- User customizable operating constraints permit sensitivity testing on positioning options - generates alternatives to maintain critical services - based on changing requirements or system degradation and addresses evolving constellation environment including satellite launch and altered coverage area
- Recalculates ground site connectivity and tracks fuel expenditure and available channel capacity
- Password protection

CONCERNS:

- Not sure what orbit propagator is inside
- Not a complete mission analysis tool

Satellite Tool Kit (STK)

CONTACT:

Analytical Graphics Inc.
George Palmer (marketing)
Doug Claffey (technical)
PO BOX 61206
King of Prussia PA 19406
(610) 337-3055
FAX: (610) 337-3058

- Comprehensive mission analysis tool with multiple external packages

PURCHASE INFORMATION:

- $7790+$1050 per yr.

SYSTEM REQUIREMENTS:

- UNIX
- PC

SOFTWARE STRUCTURE/SUPPORT:

- Object oriented design
- Support group available
- On-line help

INPUT:

- Can input ASCII data from other code and analyze
- Can accept propagator input from external program
- Database of sites/vehicles/targets available with software
- Has database of approximately 8,000 satellite and many common ground stations
- Ballistic input: initial element set with all information needed to calculate vehicle acceleration throughout trajectory through Missile Flight Tool or DAB Ascent
- Input error checking (limits of values)
- Easy input of 'today' and 'tomorrow' dates

RUN-TIME OPTIONS:

- Restart capability
- Quit/pause/return to original epoch
- Simulation runs in accelerated/real-time

OUTPUT FORMAT:

- Data stored in ASCII files
- Postscript or Encapsulated Postscript formats for printer output
- ASCII/text data
- Position output in ECC, ECEF, LLA, LLR, TOD-ECI, J2000 ECI
- Tabular output data can exported to spreadsheets, MAT-Lab, Mathematica, Etc.

CONVERSION/TRANSFER:

- Between element sets: Cartesian position and velocity/Classical/NORAD 2-line and vice versa
- Between hour-min-sec/degree-min-second to radians and vice versa
- Converts between UTC-UT1
- Converts between Calendar date with time/GMT/LST/GST/Julian Date/Day of Year
- General time and coordinate transformations

UNITS:

- Distance: AU (astronomical unit-Earth-Sun mean distance)/DU (distance unit - Earth Radii)/feet/nautical miles/statute miles/kilometers/meters
- Angle: radian/degree/arcsecond

- Time: Calendar date/Hours (for any time zone)/Minutes/Seconds/GMT/LST/GST/Julian Date/Modified Julian Date/Day of Year/UT/UTC/UT1
- Mass: Lb./Kg
- Can convert values
- Can change unit type and keep value static
- User defined distance and time units and format, can be changed in any window

ELEMENT TYPES:

- Classical Keplerian (input/output)
- Equinoctial (input/output)
- Earth Centered Inertial position and velocity (input/output)
- Earth Centered Earth Fixed position and velocity (input/output)
- Mean NORAD 2-line element set (input/output)
- Naval Space Command (PME) 1-line element set

PROPAGATOR:

- Coordinate systems: J2000.0, M1950, B1950, True of Date
- Support of higher precision propagation through High Precision Orbit Propagator (HPOP)

PERTURBATIONS:

- Perturbations up to J4, drag, sun, moon (NORAD MSGP4 or two body prop) - can choose different propagator for different objects

ORBIT DETERMINATION:

- Supported through Precision Orbit Determination System (PODS)

ATTITUDE DETERMINATION:

- Can pass in attitude data via Euler angles (AGI will help) or offset from ECI, quaternions, plus default attitude offset for ECI-Vehicle, velocity local horizontal (LVLH), ECF-VVLH, Sun-LH, ECI Euler angle and roll, pitch inertial, yaw nadir

BALLISTIC/LAUNCH TRAJECTORY:

- Ballistic trajectories for targets or launch simulations - can be used simultaneously with orbit prop
- Contains basic Ballistic/launch propagator to support generic missile launches
- Supports higher accuracy ballistic/launch simulations through Missile Flight Tool (MFT)

ORBIT MANEUVERS:

- Support for on orbit maneuvering through Navigator

PLANETARY:

- Star catalogue

OUTPUT CONTENT:

- Can save as an object or scenario (group of objects)
- Any data exportable, any graphics can be captured and exported or e-mailed, any animation recorded in RGB format and converted to many formats including MPEG for over e-mail

ANALYSES:

- Multi-site/vehicle/target simulation
- Post processor available for lon, alt, asc/desc condition, az, elevation, range, and Earth central angle at point vehicle crosses specific latitude; bit image to EPS file; printing orb elements; calculating doppler shift from az, elevation, and range file; calculates % time in sun/penumbra/umbra; generation of vehicle fixed in inertial space; constellation generator from lead vehicle from table of right ascensions and mean anomalies (different from Walker derived constellations)
- Can do analysis with areas of interest rather than single points

GROUND SITES:

- Site definition lat., lon., alt or point & click on map
- Can click on map to place ground station as well as enter lat/lon

SENSOR OPTIONS:

- Sensor pointing - nadir, off-nadir, target or vehicle tracking, can customize in polar coordinates or AZ/EL masking

- Sensor half-power beam-width and frequency or cones with inner and outer constraints (do-nut shape), clock angle limitation and minimum and maximum ranges or can custom design (help from AGI) and defined as sensing, transmitting, or receiving
- Sensors can track target - can time order: if satellite needs to see 'n' targets, STK will determine scenario that can be manipulated if required to meet your requirements

GRAPHICS:

- Az, El, Range viewing - graphical and output
- Great arc tracks for ships, aircraft, or ground vehicles
- Nice ground track + zoom and several different flat and spherical maps - user defined lat., lon. Grid
- Lighting full sunlight, umbra, penumbra - graphics and data
- Ground track depiction - full, or ascending, descending only, or none
- Visibilities graphical and output - LOS or constrained
- Ground swath graphical - can be filled
- Displays sub-solar point, solar terminator, sunlight, umbra, penumbra
- Can load DMA terrain data in VO for graphics or in background: any processor can run in background, obstruction in footprint/ground site display and algorithms, can still draw vector maps to keep graphics clean
- Graphics bold ground track when in FOV of target/ground site/AOI
- Text ID on maps and VO

FEATURES:

- Grazing angles included for satellite and Earth only - sun is additional - can be limited by min/max grazing altitude, grazing angle and ground elevation
- Wire frame sensor placement/blockage
- Walker constellation generator from lead satellite
- Access as LOS between any two points (stationary, moving, or orbiting), between any point and a sensor cone, between a point and a complex cone, between any two sensor cones (simple or complex) - ground targets can be points or area
- Can set sun constraints (min/max angle)
- Can do full battle management scenario when linked with Talon Vision (by BTG)
- Basic interface with STAMP simulation - a boost missile simulation
- Can set up pre-set viewpoints for scenario graphics ahead of time with 'flying viewpoint' script

CONCERNS:

- Only perturbations up to J4 - buy extra HPOP for more accuracy
- Must use NORAD 2 card element to use SGP4 propagator
- Ballistic propagator will give out erroneous data for some trajectories can get around by using az-el and rather than impact point
- Need outside program to define thrusting launch vehicles but can input lat/lon/alt data for display on screen

Satellite Tool Kit Programmers Lib

CONTACT:

Analytical Graphics Inc.
George Palmer (marketing)
Doug Claffey (technical)
PO BOX 61206
King of Prussia PA 19406
(610) 337-3055
FAX: (610) 337-3058

- Programmer's tools for STK applications

PURCHASE INFORMATION

- $49,200+$8856 per yr.

SYSTEM REQUIREMENTS:

- UNIX

SOFTWARE STRUCTURE/SUPPORT:

- callable by C, C++, Ada, and FORTRAN programs

FEATURES:

- Documented interfaces and modularized internals so can access all STK capabilities including object management system and graphics routines
- Allows modifications to STK to suit individual requirements
- Allows user to add functions into base-line STK
- Allows user to integrate STK into a larger system
- Allows user to use individual subroutines i.e. propagators, access routines, etc.

STK-Chains -

CONTACT:

Analytical Graphics Inc.
George Palmer (marketing)
Doug Claffey (technical)
PO BOX 61206
King of Prussia PA 19406
(610) 337-3055
FAX: (610) 337-3058

- Multi-satellite/multi-target/ground station productivity tool

PURCHASE INFORMATION:

- $1800+$270 per yr.

SYSTEM REQUIREMENTS:

- UNIX

FEATURES:

- Extends pairwise analysis capabilities of STK
- Excellent for mission analysis - i.e. viewing of any satellite in constellation and in site with ground station, etc.
- Satellite constellation visibility analysis (1x, 2x, 3x coverage)
- Ground station network visibility analysis
- Multi-hop analysis
- Relay visibility analysis
- Multi-sensor visibility analysis
- Complex connecting analysis
- Uses Boolean operators to connect objects constraints (and, or, xor, not) or 'at least' or n# in view
- Chains can be as complex as required - # not restricted

STK-Inter-Process Communications (IPC)

CONTACT:

Analytical Graphics Inc.
George Palmer (marketing)
Doug Claffey (technical)
PO BOX 61206
King of Prussia PA 19406
(610) 337-3055
FAX: (610) 337-3058

- Passes information between STK and other applications via UNIX or TCP sockets

PURCHASE INFORMATION

- $750+$115 per yr.

SYSTEM REQUIREMENTS:

- UNIX

FEATURES:

- Other applications can command STK to perform functions
- Can bring in element sets from external applications and input to STK
- Has script to read latest element sets off processor
- Can input telemetry and run STK real time with real data

STK Visualization Option

CONTACT:

Analytical Graphics Inc.
George Palmer (marketing)
Doug Claffey (technical)
PO BOX 61206
King of Prussia PA 19406
(610) 337-3055
FAX: (610) 337-3058

- 3D time driven presentation and constellation analysis environment

PURCHASE INFORMATION:

- $24,600+$3690 per yr.

SYSTEM REQUIREMENTS:

- UNIX
- Works on SUN, DEC with Denali Graphics or SGI

INPUT:

- Launch vehicle and satellite models are variable
- Can accept any commercial 3D graphics into VO proprietary language - need AGI to transfer but transfer can go both ways
- 3D models of satellites, missiles, launch vehicles, and planes/ships, submarines
- Can download NOAA cloud cover data from AGI homepage (1-3 hr old) or import more current data if needed and display on STK
- Can download Shuttle system data off bulletin board and display

ATTITUDE DETERMINATION:

- Extensive vehicle attitude modeling
- Can view satellite attitude changes - from generated model or read in actual satellite attitude data
- Can set satellite attitude nadir fixed pointing (relative to ECI velocity, ECEF velocity, sun pointing), inertial fixed (z axis fixed and X nadir pointing), or spinning or off nadir object tracking

PLANETARY:

- J2000 NASA Bright Star Catalogue with celestial right ascension/declination grid (approximately 9000 stars)
- Sun displayed with moon and moon phases (realistic moon image)

SENSOR OPTIONS:

- 3D translucent sensor cones displayed
- Instantaneous and time lapse sensor footprints and volumes
- Sensors can be target pointing, body fixed, cross-link, earth shadow, wire-frame Earth intersection, FOV, model satellite obstructions
- Pulsed beams for sensors indicating direction

GRAPHICS:

- 3D display of facilities: ground site (radome/building), tracking site (antenna), target (air field, TEL, bulls eye), image inlays (can accept satellite imagery for particular points of interest)
- Displays orbit and ground traces on spherical Earth map
- Better Earth mapping - Van Sant data and AGI relief shaded with multiple resolutions (to 1 km)
- Text ID on maps and VO
- Watch solar illumination of planets and spacecraft
- Selectable orbit and ground track display

FEATURES:

- Allows real-time program inputs to simulate operational activities

- View satellite, facilities, targets, and sensors already created in STK for animated planetary, air, space, and ground vehicle relationships
- Capture smooth animation sequences on video tape for presentation

CONCERNS:

- Only for SGI or SUN 10 UNIX workstations

STK-Precision Orbit Determination System (PODS)

CONTACT:

Storm Integration Inc.
Jim Corrigan (408) 737-8000 x221
Sandy DeSousa (408) 451-0632
Tom Martin (Software)
2025 Gateway Place
Suite 118
San Jose Ca 95110
(408) 451-0620
FAX: (408) 451-0622

- Orbit Determination add-in for STK

PURCHASE INFORMATION:

- $9840+$1,475 per yr.

SYSTEM REQUIREMENTS:

- UNIX

INPUT:

- Radar and optical data types
- Angles, range, range-rate (latter two from radar sites, laser sites and/or TDRSS)
- Optional processing of GPS data (single or dual frequency GPS pseudo range, GPS navigation data, and GPS carrier phase data including single, double and triple differences)
- Uses data from multiple sites

PROPAGATOR:

- Variable step and variable order Cowell propagator (claim theirs is highest fidelity within 1 meter)
- Optimized batch Bayesian least squares estimation

PERTURBATIONS:

- Atmospheric Drag (Jacchia 71) and solar radiation pressure (can be estimated too)
- 3rd body effects (sun, moon, any planet in solar system)

ORBIT DETERMINATION:

- Includes differential correction

OUTPUT CONTENT:

- Resulting orbits become part of STK data structures where they can be propagated

FEATURES:

- High fidelity environmental modeling
- Processing and correction algorithms from Van Martin system
- Originated with GEODYN 2 (geodetic parameter estimation)
- Can model unmodeled vectors
- Up to 99 orbits determined in single run
- Estimates sensor and timing biases, station locations, force modeling parameters
- Standard purchase or with GPS or with extended GPS capabilities
- Integrated with Storm's Intelligent Mission Toolkit and CC system to provide pointing data to the antenna

CONCERNS:

- No Kalman Filter and hard to add in, strictly a batch system (not real time system)
- Not sure if it can do space based angles only orbit determination (easy mod to add)
- Cannot add in own orbit propagator - must use theirs
- Cannot modify with STK Programmer's Library

STK - Generic Resource, Event, and Activity Scheduler (GREAS)

CONTACT:

Pacific Sierra Corporation
1400 Key Blvd., Suite 700
Arlington, VA 22209
(703) 516-6271
(703) 524-2420 fax

- Creates a customized schedule of events

PURCHASE INFORMATION:

- $8,495

SYSTEM REQUIREMENTS:

- UNIX

OUTPUT FORMAT:

- Graphical and statistical output formats

OUTPUT CONTENT:

- Outputs statistics of scheduling, # of events, percentage of events scheduled, sum duration of scheduled events, and percentage of total time scheduled for each resource
- Outputs listing of scheduled events and their start times and unscheduled events for each resource, bar charts of number of scheduled events

FEATURES:

- Parameters include duration, frequency and priority
- Priority from 0.0 to 9.0 in .1 increments
- Periodicity (frequency) defines how often event needs to be scheduled
- Last date/time scheduled
- Optimizes schedule in terms of user defined weights
- Model consumable resource capacity constraints
- Operates with STK or alone

CONCERNS:

- Does not include ground track in scheduler output (future development)
- Only Postscript format for printing

STK-SpaceVu

CONTACT:

Microcosm Inc.
2377 Crenshaw Blvd., Suite 300
Torrence, CA 90501
(310) 320-0555
FAX: (310) 320-0252
E-mail: softsmad@aol.com
http://www.sblink.com/microcosm

- Satellite visualization/orientation software

PURCHASE INFORMATION:

- $4800+$720 per year

SYSTEM REQUIREMENTS:

- UNIX

SENSOR OPTIONS:

- Can project any sensor FOV on Earth

TARGETS:

- Processes target pointing sensors from STK

GRAPHICS:

- Celestial sphere centered on satellite or ground site
- Mission geometry as seen from spacecraft itself
- Model spacecraft celestial sphere in hemisphere or as complimentary halves (good if using rotating sensors)
- Celestial sphere view can show planets, moon, sun, Earth disk with atmosphere, terminator, day/night boundary, geographic and political boundaries, ecliptic, galactic plane, equatorial plane, internal star catalog (magnitude 1.5 to 8.0), spacecraft and their orbits, Milky Way, sensor FOV, spacecraft orbit, user defined celestial objects, user input star catalog, coordinate grids
- If object is eclipsed by Earth can choose hidden or viewed (i.e. transparent Earth)
- View of satellite across sky as seen from ground site to evaluate sun interference and site passes (same option as celestial sphere)

FEATURES:

- Model Earth oriented (orbit normal or yaw steering), and inertial fixed spacecraft with fixed tracking sensors
- Pilot mode - adjust spacecraft attitude with mouse or keyboard with graphical feedback (future development)
- Coordinate grid attached to inertial space, orbit pole or spacecraft attitude
- Displays half-power and custom sensors, phase of moon, effective horizon circle, solar terminator on the Earth disk, sensor FOV's of facilities and targets, roll-pitch-yaw spacecraft planes and axial markers, direction markers for a ground station

STK-Navigator

CONTACT:

Computer Sciences Corporation
System Sciences Division
Larry Shelley
1153 Bordeaux Drive Suite 107
Sunnyvale CA 94089
(408) 734-1255
Fax: (408) 734-8803

- Designed for mission analysis and in-flight operational maneuver planning

PURCHASE INFORMATION:

- $8000 + $1600 per yr.

SYSTEM REQUIREMENTS:

- UNIX
- HP 9000 Series 700 workstations and soon on DEC Alpha and others

SOFTWARE STRUCTURE/SUPPORT:

- Operates as stand-alone or with STK

RUN-TIME OPTIONS:

- Wide range of propagation stopping conditions

PROPAGATOR:

- Propagators: Runge-Kutta Nystrom, Runge-Kutta Verner, two body

PERTURBATIONS:

- Orbit Perturbations: 21x21 geopotential (GEM-T3), DE200 planetary files, solar radiation pressure and Jacchia-Roberts atmospheric drag model

ATTITUDE DETERMINATION:

- Attitude Modes: 3 axis or spin stabilized, sun pointing and nadir pointing, or attitude input file

BALLISTIC/LAUNCH TRAJECTORY:

- Launch model
- Analyzes alternative mission profiles to determine constraints (e.g. launch windows)

ORBIT MANEUVERS:

- Can refine maneuver plans with flight-generated data such as engine, calibration parameters and actual initial orbits
- Produces thruster firing and timing data for command generation
- Combines multiple maneuvers into complex scenarios for ready comparison
- Impulsive and finite burn models

PLANETARY:

- Can be used for Earth orbits and deep space missions

GRAPHICS:

- Multiple, Simultaneous 2- and 3-D views

FEATURES:

- Follow on software to Swingby (PC based)
- Fast initial mission planner
- Targeting methods: differential corrector, steepest descent, quasi-Newton
- Maneuver calibration
- Maneuver product and ephemeris generation
- Inertial Coordinate frames: central body (Earth, sun, moon, any planet), Equinox reference (true-of-date, mean 1950/J2000), reference plane (ecliptic, central body equator)
- Non-Inertial Coordinate Frames: Earth or moon body-fixed or rotating libration point

- User definable engine model

STK-MUSE

CONTACT:

Microcosm Inc.
2377 Crenshaw Blvd., Suite 300
Torrence, CA 90501
(310) 320-0555
FAX: (310) 320-0252
E-mail: softsmad@aol.com
http://www.sblink.com/microcosm

- Mission Utility & System Engineering Module

SYSTEM REQUIREMENTS:

- UNIX

SOFTWARE STRUCTURE/SUPPORT:

- Interfaces with STK and user developed mission specific modules

OUTPUT FORMAT:

- Output data acceptable by Excel or other spreadsheet program

FEATURES

- General purpose, interactive, flexible, extensible simulation
- Provides utility software for use by user-developed modules, orbit propagation, spacecraft behavior, ground and support systems, and external events
- Can run interactively, in background, single scenario, multiple runs with one varying parameter, and Monte Carlo
- Evaluates figures of merit, mission utility, & impact of system drivers of system performance and ultimately cost
- Being developed under an AF SBIR

Satellite Test Range Architectural Planner

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

PURCHASE INFORMATION
- free

SOFTWARE STRUCTURE/SUPPORT:
- Support group existence unknown

GRAPHICS:
- Performance graphs

FEATURES:
- Evaluates test range tracking and communication capabilities
- Connectivity timeline
- **r** and **v** accuracy of track

CONCERNS:
- Station specific
- Not a complete orbit analysis program

SatLife

CONTACT:

Microcosm Inc.
2377 Crenshaw Blvd., Suite 300
Torrence, CA 90501
(310) 320-0555
FAX: (310) 320-0252
E-mail: softsmad@aol.com
http://www.sblink.com/microcosm

- Estimates orbit lifetime of satellite

PURCHASE INFORMATION

- $245

SYSTEM REQUIREMENTS:

- Mac, PC

OUTPUT CONTENT:

- Outputs lifetime estimate to screen or altitude and time data to file

FEATURES:

- Accounts for size, mass of satellite and attitude, and phase of solar cycle
- Data for tracing decay history
- Comparisons for different launch dates and orbit parameters

CONCERNS:

- Not a complete orbit package nor run in conjunction with STK

SatTrack v 4.0 (commercial version)

CONTACT:

Bester Tacking Systems (commercial version)
PO BOX 8899
Emeryville, CA 94662-8899
(510) 654-7824
Dr. Manfred Bester
bester@bester.com
http://www.bester.com/

- Configuration A - basic orbit propagation, pass prediction and collision analyses
- Configuration B - real-time tracking with text and numerical live displays
- Configuration C - world map color graphics displays
- Configuration D - graphical user interface (GUI) for interactive tracking control

PURCHASE INFORMATION:

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Configuration D - graphical user interface (GUI) for interactive tracking control
  - Graphical user interface with X11 widget set
  - Push buttons to select all features in graphics windows
  - Push button and mouse control for tracking

RUN-TIME OPTIONS:

- Configuration D - graphical user interface (GUI) for interactive tracking control
  - Reloading of satellite element sets
  - Loading of default parameters
  - Loading of ground station locations
- Configuration B - real-time tracking with text and numerical live displays
  - Fast forward mode

PROPAGATOR:

- Configuration A - basic orbit propagation, pass prediction and collision analyses
  - SGP4/SDP4 orbit propagation models with USSPC and NASA 2 line element sets

OUTPUT CONTENT:

- Configuration B - real-time tracking with text and numerical live displays
  - Azimuth, elevation, range, range rate output

ANALYSES:

- Configuration C - world map color graphics displays
  - Nearest location from ground station data base
  - Event timers
  - Dark side of Earth, terminator and sob-solar point
  - Mouse control for selecting satellites
- Configuration C -sky view color graphics displays
  - Sky view window
  - Four different color schemes
  - Elevation circles space 10 deg
  - Track of selected satellite across sky for next pass
  - Satellite lighting conditions
  - Current azimuth and elevation angles

- Indication of direction of travel for all satellites
- Event timers
- Sun, moon and lunar phases depicted
- Mouse control for selecting satellites
- Current azimuth/elevation angles
- Current latitude and longitude of sub-satellite point

GROUND SITES:

- Configuration A - basic orbit propagation, pass prediction and collision analyses
  - Min and max elevation (of station limits or of satellite pass?)
  - Az, El, range, lat, lon, height (of station limits?)

GRAPHICS:

- Configuration C - world map color graphics displays
  - World map tracking chart (2 styles, 4 sizes each)
  - Mercator projection (360x180 deg)
  - Latitude/Longitude grid lines space 30 deg
  - Six different color schemes
  - Satellite ground track for 3 or more orbits
  - Acquisition circle for any number of ground stations
  - Satellite sensor coverage for any number of satellites
  - TDRSS coverage
  - Zone of exclusion for TDRSS network
  - Configuration D - graphical user interface (GUI) for interactive tracking control
  - Mouse control for selecting satellites and ground stations
  - keyboard input for character strings
  - Message window

FEATURES:

- Configuration A - basic orbit propagation, pass prediction and collision analyses
  - GRS 80 Earth ellipsoid model
  - Long and short prediction formats
  - Output for optical and electronic sensors
  - Satellite transits in front of solar disk
  - Time zone specification
  - Specified time intervals
  - Duration of passes
  - Orbit geometry
  - Apparent right ascension and declination
  - Atmospheric refraction
  - Doppler shift
  - Mean Anomaly, radio transmission model
  - Satellite lighting conditions
  - Sun-satellite-observer angle
  - Estimated visible magnitude
  - Mission elapsed time
  - Orbit number
  - Batch model for pass prediction and collision analyses
  - GPS Dilution of Precision (DOP) holes
  - Configuration B - real-time tracking with text and numerical live displays
  - Single and multi-satellite real-time tracking display
  - Date and time, event timers for AOS and LOS
  - Mission Elapse time
  - Instantaneous state vector

- Latitude and longitude of sub-satellite point
- Grid location from ground station data base
- Orbital height and velocity
- Doppler corrected uplink and downlink frequencies
- Frequency switching and tuning
- Circumstances and lighting conditions of next pass
- Sun-satellite-observer angle
- Estimated visible magnitude
- Azimuth and elevation angles of sun/moon
- Tracking control (manual?)
- Autotrack mode

SATRAK v5.0.2 (government version)

CONTACT:

Space Warfare Center/AE
Bob Morris
(719) 567-9617
morrisrf@fafb.af.mil

- Integrated computer programs to study, analyze, and evaluate variety of space and ground related systems

PURCHASE INFORMATION:

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- On-line information for quick user reference to SATRAK organization and functions
- Menu driven with mouse or arrow keys
- Future version will be full Microsoft® Windows™ compatible - but currently can be executed within Microsoft® Windows™ through .PIF
- Menu driven

INPUT:

- ASCII files used in versions prior to 3.0 are external files used for importing and exporting data from SATRAK - prior files can not be read directly by SATRAK
- Can read element sets from file, input from key board, or user element set generated to produce element sets from launch data, or lat, lon, period, and inclination information

OUTPUT FORMAT:

- Can plot data and graphics to flat bed plotters, laser printers, and computer screens

ELEMENT TYPES:

- Uses NORAD element sets

PROPAGATOR:

- ESTIMATE DECAY calculates expected orbit lifetime using either ballistic coefficient or N./2
- Propagators: SGP4, SGP, 2 body and 2 body plus J2

BALLISTIC/LAUNCH TRAJECTORY:

- Can analyze missile projectile flight from 2 different perspectives included with a simple range calculator

GROUND SITES:

- LAMOD produces ground sensor contacts

SENSOR OPTIONS:

- SENSOR COVER calculates the sensor coverage volume plot data for a given altitude based upon sensor inputs

GRAPHICS:

- SENSOR VIEW graphics provide differing aspects of satellite passes across the sensor (for LAMOD) or satellite (for COMBO) coverage area - Plots depicting azimuth, range, and elevation information are available
- MAPS graphics module provides Cartesian maps over entire world or user specified geographic area depicting ground track and sensor coverage areas (TRACK/SENSOR COVER). Satellite locations, passes, and sensor coverage
- 3D VIEW graphics module produces orthographic projection of a 3D world and satellite orbits - both orbit track and ground traces can be displayed

FEATURES:

- Completely validated against SPADOC4 with documented test cases
- TRACK generates satellite latitude, longitude, and altitude
- COMBO provides satellite to satellite contacts within a user specified sphere of interest
- Earth radius, Earth flattening, gravitational constant, and zonals may be based on WGS 72 or WGS 84 constant values

USERS:

- Supported by HQ US Space Command and US Army Space and Strategic Defense Command
- Over 200 users: Pentagon, CIA, Fylingdales, AFSPC, and USSPACECOM

SATVIS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Sat-Sat visibility

PURCHASE INFORMATION:

- free

SYSTEM REQUIREMENTS:

- CDC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

CONCERNS:

- Not a complete orbit analysis package
- Not really for external use

SCATLW

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Robert Gist
(310) 336-4297

- Sun constraints and launch window analysis

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- CDC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

CONCERNS:

- Not a complete orbit analysis package]
- Not really for external use

SCOOP

CONTACT:

The Aerospace Corporation
Tom Lang
(310) 336-4307
PO Box 92957
Los Angeles CA 90245-2957

- Generates optimal symmetric constellations of many satellites for continuous global or zonal coverage

PURCHASE INFORMATION:

- Free to U.S. government users

SYSTEM REQUIREMENTS:

- PC

CONCERNS:

- Not a complete orbit analysis package

SEQ-GEN

CONTACT:

Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena, CA 91109

- Multi-mission discrete event simulator

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- Sun Sparc, HP

SOFTWARE STRUCTURE/SUPPORT:

- UNIX based

INPUT:

- Smart editor for sequence updates
- Easy to adapt and user interactive and graphic interface (X/Motif)

FEATURES:

- Converts high level requests into spacecraft commands
- Performs flight rule checks

CONCERNS:

- Not commercially available
- Not tied into a comprehensive orbit analysis program

Simple Orbital Density Model for Drag Equations

CONTACT:

NASA & TRW
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

PURCHASE INFORMATION

- free
- Cost for non-government: $300 + $15 documentation
- Cosmic order #MSC-21154

SYSTEM REQUIREMENTS:

- HP9000, Sun

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77

INPUT:

- Inputs F10.7, altitude (meters), and geomagnetic (Ap)

PERTURBATIONS:

- Simplified Jacchia 1970 - daily averaged density - average density at that time of year

FEATURES:

- Solar activity (F10.7) and geomagnetic activity
- Diurnal effects averaged out
- Altitude range: 100-1,000 km
- Does not need right ascension, declination of sun - reduced computation time
- 5% accuracy to real Jacchia

SMART

CONTACT:

Space Applications Corp.
891 Elkridge Landing Road, Suite 145
Linthicum MD 21090
(410) 684-2062

- Ephemeris generation for multiple vehicles

SYSTEM REQUIREMENTS:

- SUN,PC

GRAPHICS:

- Displays ground track, sensor footprints, and sensor swaths
- Variety of world map projections

FEATURES:

- Uses ORACLE database to manipulate data

CONCERNS:

- Propagator only two body with J2
- Only used in-house - not distributed
- Software no longer maintained by Space Applications Corporation

SORT

CONTACT:

NASA & Lockheed Engineering and Sciences Co
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- Simulation and optimization of rocket trajectories V7.0

PURCHASE INFORMATION

- free
- Cost for non-government: $700 + $135 documentation
- Cosmic order #MSC-22496 (VAX), MSC-22497 (HP9000 700/800 series), MSC-22498 (Cray)

SYSTEM REQUIREMENTS:

- HP9000, Cray, VAX VMS
- Requires Stanford University's NPSOL to run

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN 77

OUTPUT FORMAT:

- Tabular output in many formats
- ASCII trajectory summary output
- Binary output for plotting

PERTURBATIONS:

- 4 atmosphere models - 2 table models

BALLISTIC/LAUNCH TRAJECTORY:

- 3DOF aerospace vehicle flight dynamics
- Numerically models: propulsion, guidance/steering, static moment balance - atmosphere, drag, gravity, winds for rotating planet
- Targeting and optimization capability with non-linear constraints
- Longitude/latitude forces and moments
- Simplified ballistic re-entry
- Engine deflection angles
- Thrust deformation model
- Throttle/non-throttle
- Up to 15 mass subsystems - inert or propellant with center of mass history
- Any parameter can be a constraint or optimization parameter
- Up to 15 engines (liquid, solid, mono/bi propellant) - can adjust flow rate, thrust, chamber pressure tables to compensate ambient temperature and burn rate changes

FEATURES:

- Validated and verified
- Up to 7 levels of optimization
- 6 iteration/optimization techniques

USERS:

- Used at Mission Operations at Johnson Space Center, shuttle operations, and Advanced Launch System concept development

Spacecraft Cost Engineering and Estimating Design (SCEEDOS)

CONTACT:

Technomics Inc.
5290 Overpass Rd #206
Santa Barbara, CA 93111
Gene Waller
(805) 964-9894

- Cost engineering improves the design and engineering process while cost estimating produces cost assessments for a given design

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Menu driven under Microsoft® Windows™
- Future models on Macintosh and UNIX

FEATURES:

- Used as Programs for Unified Life-cycle Systems Engineering (PULSE)
- Uses analytic models that describe subsystem in terms of technical equations, estimating equations and weight estimating equations - also shown in form of constraints on specific variables and if-then rules can be applied
- Allows systems analyst ability to specify a system architecture to satisfy a given mission or set of missions by describing requirements of mission
- Analytic framework that supports and structures cost engineering problems
- Infinitely extendible by providing easy access to any external application or function that the analyst desires (i.e. orbital graphics program)
- Many generic mission, payload technology, spacecraft bus, and orbit mechanics technology types are built in
- Nonlinear optimization algorithm with text and graphical output - use minimum and maximum settings for parameters: expanding them can lead to unfeasible solutions and limiting them can artificially constrain the solution and starting values can effect efficiency and solution of optimization
- Parametric sensitivity analysis - choose parameter to vary and view effects on other parameters
- Cost graphs in pie, bar, etc., for subsystem makeup of total cost
- Uses PC SOAP to display animated constellation of satellite - integrated through SCEEDOS input
- Utilities offer functions for changing parameters of the optimization algorithm, changing the optimization algorithms used, indexing the databases, and altering the system settings

CONCERNS:

- More a cost analysis not a mission analysis program

Space Forces Engagement Model (SFEM)

CONTACT:

Space Warfare Center/AE

SYSTEM REQUIREMENTS:

- VAX

FEATURES:

- Designed for ASAT scenarios

CONCERNS:

- Not a complete orbit analysis package
- No maintenance support
- Does not model ICBMs or BMD interception

Space Mission Expert (SMX)

CONTACT:

Evergreen Engineering
Mr. Sven Grahn, M. Sc.
Rattviksvagen 44
S-191 71 Sollentuna
Sweden
Fax:Internat. Code + 46-8-754 19 04

PURCHASE INFORMATION:
- $400

SYSTEM REQUIREMENTS:
- PC

SOFTWARE STRUCTURE/SUPPORT:
- Microsoft® Windows™ version in progress

OUTPUT FORMAT:
- Stores data in files
- Output ECI or osculating **r** and **v**
- Print graphics to PostScript, HP LaserJet, dot matrix, or to disk files

CONVERSION/TRANSFER:
- ASCII NORAD 2 line element sets can be converted to SMX format

PROPAGATOR:
- SGP propagator

ORBIT MANEUVERS:
- Impulsive orbit adjust

GRAPHICS:
- Ground track with zoom, flat or spherical map
- Plots eclipse duration as a function of time
- Time in view of site - nice graphics
- Simple and complex continent files

FEATURES:
- Relative motion between satellites
- Look Angles from site: az, elevation, range, range-rate
- Displays sub-satellite point
- Illumination at satellite including total time in eclipse
- Satellite and site database
- Can run satellite in real-time
- Sub-window with satellite access to target
- Magnetic field at satellite + field line footprint
- Spacecraft footprint displayed at user-defined intervals along the track
- Site visibility horizon defined in terms of min elevation angle
- The solar terminator and eclipse zone are displayed on single satellite real-time display (updated every 5 min)
- Eclipse start and end points are shown as arrows along the ground track
- Text file viewer
- Modified to support real-time operations (FOSS): generates timelines for switching transmitters on and off, the best time for collecting attitude sensor data, generates magnetic torquer commands for reorienting spin axis, predictor for gravity-gradient spin vector drift effects, etc.

CONCERNS:

- No support group
- No finite burn model

SPACENET Simulation

CONTACT:

General Research Corporation International Inc.
PO Box 6770
Santa Barbara, CA 93160
Dr. G. E. Shortle
Dr. Harry Burger
(805) 964-7724

SYSTEM REQUIREMENTS:

- VAX/VMS,PC and SGI UNIX

SOFTWARE STRUCTURE/SUPPORT:

- # satellites, sensors, sites, and missiles limited only by memory

INPUT:

- Uses NORAD 2 line element set and SpaceCom B3 format for observations
- Standard input files for sensor and object characteristics exist for all US sensors and satellites

SENSOR OPTIONS:

- Evaluates existing sensor capabilities and deficiencies and impact of updated or new sensor capabilities
- Models: sensor scheduling, measurement , tracking functions, missile/satellite propagation (Space command propagators), dynamics, signature characteristics, environmental effects, and solar/lunar/stellar backgrounds, digital communications between network sensors and central site, command /control processing, element set estimation and maintenance, new launch and maneuver processing, space object id.
- Space based sensors can be included
- FOV entry/exit mode: sensor measurements generated, sensor track accuracies, observations sent to the central command and control facility, satellite element sets generated, and sensor tasking performed by central facility
- Other modes: sensor sensitivity, individual sensor tracking, sensor network
- Event based simulation - may run slower than real-time with large numbers of sensors

GRAPHICS:

- Display with X-Windows based programs - maps plot, current central and sensor site status, and network messages

FEATURES:

- Communication and processing delays are automatically included in model
- Programming allows additional functions and modifications
- High fidelity simulation of sensor network response (radars, electro-optical sensors, and communications, command, and control) to detected space objects (spacecraft, missiles)

CONCERNS:

- Written in GRD SIMULTRAN then translated into FORTRAN
- Propagators may not have accuracy needed for useful studies
- May run very slow for extensive analyses
- Not sure of graphics of program

SPASIS

CONTACT:

NASA & Lockheed Engineering and Management Service Co
(706) 542-3265 (Product Info)
FAX: (706) 542-4807
email: service@cosmic.uga.edu

- 6DOF Earth orbiting simulation

PURCHASE INFORMATION

- free
- Cost for non-government: $8,000 + $97 documentation
- Cosmic order #MSC-21462

SYSTEM REQUIREMENTS:

- Dec VAX 8650

SOFTWARE STRUCTURE/SUPPORT:

- Menu driven
- Written in FORTRAN 77 with 1% VAX dependent language

INPUT:

- Data file inputs: orbit parameters, mass, reaction control system size and placements, control moment gyros specification, docking parameters, propulsion tank and liquid definitions, jet characteristics, maneuver requirements, mobile mass movement, secondary vehicle definition, articulating component specifications
- Input matrix of grid points and surface area model define spacecraft configuration

OUTPUT FORMAT:

- Many text output options/binary plot data

PROPAGATOR:

- Orbit equations of motion, attitude quaternion rates, gimbal rates - Runge-Kutta-Gill 4th order integrator

PERTURBATIONS:

- Forces: gravity, environmental, propellant slosh, docking, plume impingement, control system
- Perturbations: Environmental torque, panel articulation, propellant/mass motions, plume impingement, docking, Jacchia atmospheric drag, sun tracking radiation

FEATURES:

- Plot package included
- Space Systems Integrated Simulation

SPS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957
Carl Billingsley
(310) 336-1589
Willard Downs
(310) 336-5320

- Simulation Planning Software

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- CDC

SOFTWARE STRUCTURE/SUPPORT:

- Written in FORTRAN

FEATURES:

- Orbit mechanics

CONCERNS:

- Not a complete orbit analysis package
- Not really for external use

Strategic and Theater Attack Modeling Process (STAMP)

CONTACT:

Lt. Kenyon Orme
kso535@naic.wpafb.af.mil
(513) 257-2356
787-2545 DSN
NAIC/TABS
4115 Hebble Creek Rd Suite 24
Wright-Patterson AFB, OH 45434-5628

- Models all kinds of missiles

SYSTEM REQUIREMENTS:

- SGI,SUN

BALLISTIC/LAUNCH TRAJECTORY:

- Booster modeling - guidance (fly by wire, thrust termination, pitch, yaw), reads FASTC Missile Definition Base (MDDB), multiple thrust levels, mass changes, staging, flight controls, etc., system peculiar characteristics, over 20 boot parameters available for plotting
- Post-Boost vehicle modeling - event based simulation defined by MDDB, single or multiple PBV's, multiple RV tiers, object deployment - RV's, debris, penetration aids, 3 DOF plus tracking PBV command attitude, over 10 parameters available for plotting
- Force laydown modeling - both strategic and theater attacks, incorporates existing aimpoint of facility data bases, assigns boosters and RV's from launch complexes to aimpoints considering - attack philosophy and goals, target priorities, weapons types, capabilities, locations, and inventories, criteria for launch point/area selections, aimpoint hardness characteristics, desired damage levels, attack timing.; allows users to select weapon assignments, produces realistic boost times, RV deployment and TOF, automatically checks feasibility of attack.
- Outputs trajectory profiles, bounding performance plots, threat complex descriptions, attack allocations, scenario taps, attack characteristics.

USERS:

- Many military users

CONCERNS:

- Not a complete orbit analysis package

STAVIS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Station visibility

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- IBM 3090

ANALYSES:

- Rise/set times

GRAPHICS:

- Visibility characteristic plots

CONCERNS:

- Not a complete orbit analysis package
- Not really for external use

SUPERTOPS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Minimum Delta V transfer for inclined-elliptic orbits

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- IBM 3090

CONCERNS:

- Not a complete orbit analysis package
- Not really for external use

Surveillance Analysis Tool (SAT)

CONTACT:

Nichols Research
John McIntire
1535 Vapor Trail
Colorado Springs, CO 80916
(719) 597-2585
Capt Gary Wilson
USSPACECOM/DOYO
150 Vandenburg St. Suite 1105
Peterson AFB, CO 80914-4110
(719) 554-5211 (DSN 692-)

- Re-hosting of SGP4 to Silicon Graphics machine

PURCHASE INFORMATION

- $5000

SYSTEM REQUIREMENTS:

- SGI

INPUT:

- Database: SSN catalog
- CMAFB, CACS SATCAT element set and RCS data file interface

OUTPUT FORMAT:

- Tabular output of lat/lon, sensors viewing satellite, satellite in coverage, look angles by satellite, look angles by sensor, coverage statistics, time to element set 1

SENSOR OPTIONS:

- SSN coverage analysis for sensor and RSO suites: % coverage, culmination, and exit times and look angles, and single/dual/or greater coverage
- Geosynchronous coverage, static polar view of geosynch sats, sunlight model for optical sensors (Earth eclipse included)
- Space based sensor analysis - sensor pointing, Earth exclusion, rectangular/conical/planar sensors
- Foreign launch analysis - site database, time to element set 1 computation, support NFL sensor importance, impact of closing/adding or moving sensors
- Sensor site location/type and physical limits analysis: % coverage, sensor coverage volumes graphics, graphic coverage volume with Earth or specified altitude with given altitude above Earth's surface
- Sensor searches by name/defined class/parameter

GRAPHICS:

- 3D maps
- Cartesian, spherical Earth (rotating or fixed), or equal latitude map with grid/solar terminator
- Display satellite position, SATCAT #, ground trace, ephemeris, orbit plane in 3D view
- Output 2D graphs of RSO altitude, latitude, or longitude vs. time; RSO coverage vs. time

FEATURES:

- RSO orbit and ephemeris generation and graphics: launch mission orbit planes (initial, transfer, parking), instantaneous velocity maneuvers, variation of element set parameters for training
- Random RSO type/class population increase: bulk increase, variation of Argument of perigee/mean anomaly/right ascension of asc. Node
- Satellite search by SATCAT #, RSO class/parameter
- Database sort/search capable of complex unions and intersections
- Sort by country/lon for geo/string in inter. desig/SATCAT #
- Can create/modify user satellite

- Display sensor position/designator/orbit coverage/Earth projection/Coverage shading for 2D maps/ volume for

USERS:

- PL/VTS is getting source code

CONCERNS:

- Rehosting of same NORAD propagators
- Not sure if sensor coverage analysis for elliptical orbits (analytical method may be for altitude input only)
- No longer under AF development/maintenance contract

System Effectiveness Model for GPS (SEM)

CONTACT:

ARINC Inc.
4055 Hancock St.
San Diego, CA 92110
Hana Maquet
(619) 222-7447

Global Positioning System visibility and navigational accuracy analysis

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Menu driven with arrow keys movement

INPUT:

- Includes Almanac and Status Update (ALMSTAT) utility to download current satellite orbit and status directly from GPS satellite or from other sources

OUTPUT FORMAT:

- Can save and customize plots and program options

GRAPHICS:

- Dilution of precision (DOP)plots
- Satellite az-el plots and tables for fixed sites
- Satellite elevation versus time plots
- Graphics of cumulative world map and plots

FEATURES:

- Portable to help plan using the GPS constellation to predict GPS performance
- Plans operations and explore capability and potential uses of GPS
- Forecasts GPS availability and accuracy of GPS for any global location and for any date or time
- Satellite coverage can be plotted to determine the best performance windows
- Can be tailored to specific GPS receivers
- Navigation accuracy by time/date/region
- Satellite rise-set times for fixed sites
- Number of visible satellites for fixed sites

CONCERNS:

- Not a complete orbit analysis package
- Does not have a database history - so if analyzing past data, the constellation will not change over time to show updates in constellation

System for Interactive Multispectral Analysis (SIMAN)

CONTACT:

Space Warfare Center/AE

FEATURES:

- Orbit mechanics, satellite mission planning, satellite-network planning, spatial and orientation relationships, satellite ID and assessments, sensor coverage analysis
- Includes Earth, sun, moon, stars and planets - Mathematical solar system
- Satellites - orbit traces, ground swaths, visibility lines, standard and custom element sets
- Sites, sensors, and platforms with user definable geometries
- Missiles and moving object modeled
- Thrusting ballistic Missile, LCU, Non-informed Foreign Launch, and ASAT simulations
- Mission planner
- Satellite builder
- Constellation builder
- Differential correction module
- Look angle module
- Computation of miss between orbits, predictive avoidance module Spiral decay module
- Estimate decay module
- Interactive windows
- File export for LWIR and photometric signature data

System Testability and Maintenance Program (STAMP)

CONTACT:

ARINC Inc.
4700 Roseville Rd Suite 107
Sacramento, CA 95660
Brian Pickerall
(919) 850-0053

- Software system that evaluates system testability and develops fault-diagnostic strategies

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- PC

SOFTWARE STRUCTURE/SUPPORT:

- Can provide technical order manuals, ATE test program sets, and intelligent maintenance aids

GRAPHICS:

- Visual astrodynamic application - 2D and 3D views
- Perspective can be tied to a platform

FEATURES:

- Assessment of inherent system capability to isolate faults and guidance to decide where additional test points are required
- Supported testability design reviews, failure modes and effects analyses, built-in test evaluations, and development of portable maintenance aids
- Successfully applied to more than 50 systems - from component to system level
- Provides more than 20 measures reflecting inherent testability of system or equipment: isolation level, test uniqueness, excess tests, component not detected, operational isolation, false-alarm tolerance
- Identifies component ambiguity groups, redundant tests,. feedback loops, and their components
- Performs sophisticated multiple failure analysis for root causes and false failures
- Provides optimum order for conducting tests to isolate failures, can be weighted with predicted/actual test failure rates, test times, and test costs
- POINTER is portable intelligent maintenance aid using STAMP generated dependency model as knowledge base - can be embedded into system processors

CONCERNS:

- Not a complete orbit analysis package

Tactical Warning Simulation Model (TWSM)

CONTACT:

Teledyne Brown Engineering
Colorado Springs, CO 80910-3799
Space Warfare Center/AE

SYSTEM REQUIREMENTS:

- VAX

SOFTWARE STRUCTURE/SUPPORT:

- Documentation with user manuals
- Menu driven and file based
- User interface menu driven, flexible file based data flow, common interfaces, plug-compatible modules

INPUT:

- Inputs are scenario, stress, communication network, missile flyouts generated from ATTACK, thrusting objects, orbiting satellites, and radar cross sections

OUTPUT FORMAT:

- Hardcopy from interactive display
- Table and plot output

SENSOR OPTIONS:

- Sensor Model: transforms threat data into sensor messages, pulse by pulse modeling, pixel by pixel modeling, includes medium and high fidelity models
- Sensor model radar feature: observations pulse by pulse, includes closely spaced objects, radar schedulers, radar processing (queues and buffers)

FEATURES:

- Attack model: high fidelity model with documentation and user manuals: missile launches and trajectories, RV deployments and trajectories, object trajectories, and booster and object signature output
- Communications Module: Detailed communication topology, processes actual messages, simulates protocols, includes buffering and queuing, includes direct stress effects (blast, thermal, EMP), allows for alternate routing
- Coverage Module: reduces runtime by minimizing trajectory calculations, applicable to both medium and high fidelity models
- Stress Module: Sources (nuclear detonations, electronic countermeasures, sabotage, natural environments, reliability and maintenance outages), categories (direct on/off effect, radar propagation effects, communication propagation effects, satellite sensor effects, radar effects modeled in the medium fidelity model (attenuation due to absorption, noise fireball/jamming), radar effects modeled in the high fidelity model (attenuation due to absorption and scattering, noise fireball/jamming, clutter, Faraday rotation, propagation delay, refraction, multipath interference
- Stress inputs are NUDET time, location, and yields or vulnerability threshold parameters, link/node data, fireball data, ECM events, node direct damage events, link direct damage events, NUDET events, weapon data

CONCERNS:

- Difficult to add new missile types
- Comm module does no model ID message sets, atmospheric/space environment, MILSTAR, nor current ITW&A system
- Difficult to implement new message protocols
- Coverage module applicable only to Attack file format
- Interface is non-iterative with End-To-End models

Test, Research and Analysis of Celestial Kinetics for Spacetrack (TRACKS)

CONTACT:

Space Warfare Center/AE

PURCHASE INFORMATION
- free

SYSTEM REQUIREMENTS:
- VAX,Gould,RS-6000

SOFTWARE STRUCTURE/SUPPORT:
- Written in FORTRAN

INPUT:
- Inputs in NORAD 2 line element set or ECI position and velocity vectors

PROPAGATOR:

Propagators - 2 body, SGP4, HANDE, SALT/PEPPER, Special Perturbations (SP00X)

PERTURBATIONS:
- Can include drag, radiation pressure, solar lunar third body, solar flux, average solar flux, planetary magnitude index, Kappa value, geopotential control, outgassing, and precession/nutation interval perturbations

ORBIT DETERMINATION:
- Differential Correction - bias Boolean, weight Boolean, epoch time, element correction flags and order, residuals criterion flag, plot control flags, divergence control flags, sort input observations, debug flag, numerical partials Boolean, percent of residuals acceptable, DC method flag, DELTA/SCC calculation flag, delta time rejection criteria, residuals rejection flag, ephemeris generation Boolean, drag flag, convergence time criteria, convergence element criteria, pseudo element generation flag, maximum number of iterations

FEATURES:
- Used as a baseline for SPADOC numerical validation and day to day production runs and development of new astrodynamic algorithms
- Can define output coordinate system, time off element set, reference coordinate system, integrator control flag, HANDE OD interval, missile trajectory Boolean, and step size control data, Legendre or Chebyshev coefficients
- Computation of Miss Between Orbits - compares orbit of designated primary satellite with the orbits of a selected list of other satellites; determines times when the primary satellite passes within a distance of any of the secondary satellites; warn of sustained relative orbits; computes distance, velocity, delta time, delta plane, delta height, position and velocity components, latitude/longitude and height, position and velocity of the secondary satellite in the coordinate system of the primary satellite
- Look Angle Module - determines when satellite visible to ground sensor; computes with respect to sensor location: satellite rise/set times, satellite culmination time, sensor look angles (az/elevation/range/range-rate), sunlight illumination for both sensor and satellite
- Can have up to 3 limit parameters on ground sensors with range limits
- Predictive Avoidance Module - calculates time periods (windows) in which any number of secondary satellites will pass near a line of sight between the sensor and a primary satellite - can define laser danger zone with laser power, intruder threshold, beam divergence
- Report Association Module - associates observations against existing element sets - used to maintain space catalog
- Spiral Decay Module - performs DC for use with special perturbations similar to DCMOD but special perturbations assumed and weights and biases are required

CONCERNS:
- Inadequate documentation
- Fixed case sizes (LAMOD 10 satellites/10 sensors)

- Card/file based interface
- Uncontrolled versions in other software packages

TOES

CONTACT:

United States Air Force
PL/VTS
3550 Aberdeen
Kirtland AFB, NM 87117-5776
(505) 846-7990

PURCHASE INFORMATION
- free

SOFTWARE STRUCTURE/SUPPORT:
- FORTRAN
- Well documented source code and user manual available

INPUT:
- Multiple burn magnitudes and directions through simple input file

OUTPUT FORMAT:
- Tabular output set up so easily portable to Excel for plotting

PROPAGATOR:
- Two body or analytical J2 propagator available

FEATURES:
- Determines time off element set - difference in rise time at specified ground station due to orbit maneuver
- Iterates time of burn from user specified time before rise to time of projected rise at site

CONCERNS:
- Not a complete orbit analysis package
- No graphics attached - must plot through outside program
- Burn direction limited to simple intrack, radial, or crosstrack burns

TOPS

CONTACT:

The Aerospace Corp.
PO Box 92957
Los Angeles CA 90245-2957

- Minimum Delta V transfer for inclined-circular orbits

PURCHASE INFORMATION

- free

SYSTEM REQUIREMENTS:

- PC

CONCERNS:

- Not a complete orbit analysis package
- Not really for external use

TRACE

CONTACT:

The Aerospace Corp.
John Langer
(310) 336-6336
Jesse Cook
(310) 336-6385
2350 East El Segundo Blvd.
El Segundo CA 90245

PURCHASE INFORMATION
- free

SYSTEM REQUIREMENTS:
- Sun

UNITS:
- English or metric units
- Internal units are DU and TU in Cartesian coordinates

ELEMENT TYPES:
- Orbital elements in Keplerian, Cartesian, flight parameters, orbit-plane, GPS, NORAD two card set

PROPAGATOR:
- Runge-Kutta 4 start up with 10th order Gauss-Jackson differencing scheme to numerically integrate equations of motion

PERTURBATIONS:
- Propagate with up to 350 spherical harmonics, drag, solar radiation pressure, solar/lunar gravity

ORBIT MANEUVERS:
- Orbit adjust capability - impulse or finite burns - in or out of orbit plane

FEATURES:
- Ephemeris for sun, moon, and planets
- Eclipsing calculated
- Sat-sat and sat-site visibility look angles and range
- Time and distance to closest approach between two satellites
- Multi-satellite for constellation analysis

CONCERNS:
- No tools to facilitate orbit maintenance or design orbital parameters to meet mission
- No graphic capability
- Documentation incomplete
- For internal use only

Wings Mission Rehearsal

CONTACT:

Autometric Inc.
5301 Shawnee Rd
Alexandria, VA 22312-2333
(703) 658-4000

PURCHASE INFORMATION:
- $30,000

SYSTEM REQUIREMENTS:
- SGI

SOFTWARE STRUCTURE/SUPPORT:
- Interactive window based

INPUT:
- Interfaces with TRAP/Constant Source and National Imagery Transmission Format (NITF) data

OUTPUT FORMAT:
- Hardcopy output

GRAPHICS:
- Receiving ELINT data and superimposing onto 2D and 3D terrain imagery
- Capturing and storing secondary imagery

FEATURES:
- Video loop generation
- Movie files

CONCERNS:
- Not a complete orbit analysis package
- SGI only
- Requires data preparation including pre-processing and formatting of data using other image processing packages (ERDAS)
- Soon to be absorbed in Edge with Omni

Wintrak Pro for Windows™ 95

CONTACT:

WINTRAK
Paul Traufler
111 Emerald Drive
Harvest, AL 35749
(205) 837-0084
(205) 726-5511

PURCHASE INFORMATION:
- $69.95

SYSTEM REQUIREMENTS:
- PC with Microsoft® Windows™ 95

INPUT:
- ASCII data file to edit elements / NORAD 2 line element set
- External module to download from NORAD element sets

CONVERSION/TRANSFER:
- Has module to convert from R and V in any coordinate. system to NORAD element set

PROPAGATOR:
- SGP4/SDP4 - unknown origin

GRAPHICS:
- Shows sun terminator
- Zoom only to US on Mercator projection ·

FEATURES:
- Pass plan for a ground station/ground operations
- 10 satellite with one site or 2 satellites with 3 sites
- Reads system clock on computer
- Work through network time clock and download
- Stars from satellite point of view
- Visibility settings - LOS only or optical sensor
- Displays time to next pass - maximum elevation, min range and duration of pass

CONCERNS:
- Not a mission analysis tool
- No Delta V capability
- Unknown if SCN is a user
- Propagator gives them 20 sec accuracy with 10 day old element set

Index of Software by Function

COORDINATE/ELEMENT TRANSFER
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GEODYN
NOVAS
Orbital Workbench
OSMEAN
PSIMU v4.0
REDUC
WINTRAK

ENVIRONMENT & DEBRIS ANALYSIS
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Debris Cloud Simulation Tool (DCSIM)
Debris
EPSAT
EWB
IMPACT
Initial Space Safety System
Integrated Debris Evolution Suite (IDES)
KSAT
Methods of Astrodynamics
MinRng
NASA IDEAS
NORADC
Orbit II Plus
Orbit Works
PCOrbit
Probabilistic Evaluation of Risk for Collisions Tool (PERFCT)
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DPTRAJ/ODP
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LOTHRST
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DAB Ascent & Database
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LIBRARY OF SOFTWARE COMPONENTS AND SOFTWARE ANALYSIS
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Portable Interactive Troubleshooter (POINTER)
PCOrbit
PSIMU v4.0
SATBASE
STK Programmers Library
STK - Interprocess Communications (IPC)
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System Testability and Maintenance Program (STAMP)

Teledyne Brown Engineering

LIFETIME
Decay
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Lifetime
NASA IDEAS
Orbital Lifetime Program
SatLife
SIMAN

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ON-ORBIT OPERATIONS & DATA ANALYSIS

Advanced Simulation Development System (ASDS)
Communications Link Analysis and Simulation System (CLASS)
Cyberspace Data Monitoring System
Defense Support Program Medium Fidelity Model (DSP MFM)
Edge]
EncounterVUE
ERDAS
Flight Dynamics System (FDS-Telesat)
Force Management System (FMS)
GTARG
Initial Space Safety System (ISSS)
Integrated System Manager (ISM)
LinkWinds
Mercator
OASIS-CC
OASIS-Mission Scheduler
OASIS-PS
OASIS Telemetry Data Display Analysis
ORAN
Orbit Analyst Workstation (OAWS)
PSIMU v4.0
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Satellite Planning Decision Support System (SPDSS)
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SPACENET Simulation
System Effectiveness Model for GPS (SEM)
Tactical Warning Simulation Model (TWSM)
Wings Mission Rehearsal

ORBIT DETERMINATION
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DPTRAJ/ODP
Dynamo
Flight Design System (FDS - Aerospace Corporation)
Flight Dynamics System (FDS-Telesat)
GEODYN
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Methods of Astrodynamics
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ORBIT PROPAGATORS (Very High Precision)
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TIMELINE
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AXIS
DAB Ascent
Flight Dynamics System (FDS - Telesat)
Forest And Trees
KRONOS
OASIS-PC
OASIS Mission Scheduler
Orbit Works
PLAN-IT-II
Satellite management System (SMS)
STK - Generic Resource, Event, and Activity Scheduler (GREAS)
SEQ-GEN
SPACENET Simulation

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